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ABSTRACTS
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37th ANNUAL MEETING

OF THE

AMERICAN CERAMIC SOCIETY

HOTEL STATLER, BUFFALO, N. Y.

WEEK OF FEBRUARY 17, 1935

AND ANNUAL MEETING OF THE

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MAGNESIA REFRACTORIES IN BASIC OPEN-HEARTH STEEL FURNACES*

By Olaf Andersen

ABSTRACT

By microscopic examination of new and old magnesia bottoms of open-hearth furnaces it has been shown that the periclase (MgO) and the slag matrix in the bottoms undergo considerable changes during the campaign of a furnace. The periclase absorbs large amounts of iron oxide. Thus examples described show that the iron oxide (contained in solid solution as $MgO \cdot Fe_2O_3$) in periclase may be 3% in dead-burned magnesia, 9% in a new bottom made of a 3:1 magnesia-slag mixture, and as much as 50% in the upper layers of an old bottom. At the same time the microstructure of the bottom changes materially. The periclase in a new bottom occurs as separate, rounded grains of diameters up to 0.2 millimeter, each grain entirely surrounded by a silicate matrix which is liquid at furnace temperatures. The periclase grains in the upper layers of an old bottom may have diameters up to 0.5 millimeter; the grains are no longer separated, but are joined to a more or less continuous aggregate while the silicates (together with some calcium ferrite) now may be gathered in scattered aggregates often surrounded by periclase. The changes have been produced by the influence of slags high in iron oxide and lime. Sometimes these slags have penetrated through cracks or pores to the deeper layers of the bottom where they have changed parts of the bottom to a dark aggregate containing a periclase high in iron oxide. Reducing gases given off by the molten metal may also have produced changes in the bottom especially by reducing the iron oxide in the periclase from the ferric to the ferrous state and thus imparting a light color to this dominating constituent and to the aggregates in which it occurs. These light aggregates are often irregularly mixed with the dark aggregates formed through the influence of slags.

Studies have been made of the reactions between magnesia brick used in end walls of open-hearth furnaces and the furnace dust, rich in iron oxides, which accumulates on the inside surfaces of the walls. The reactions result in a gradual melting of the magnesia brick. Magnesioferrite-magnetite solid solutions and periclase-magnesioferrite solid solutions partake, together with silicates, in this process of melting. The solid solutions must be formed before any appreciable melting of the magnesia in the brick can take place. The rate of melting will depend largely upon the rate of formation and the ultimate properties of the solid solutions. Low porosity of the brick and an oxidizing atmosphere are likely to prolong the life of the brick.

I. Introduction

All magnesia-bearing refractories undergo considerable changes when used for any length of time in places where they are exposed to high temperatures and to the influence of slags and furnace dust that come in contact with them. Several features of these changes may be studied by examining under the microscope samples of refractories collected from basic open-hearth steel furnaces at various parts of the furnaces and at several stages during their campaigns. In the present paper some of the results of such studies, carried out at the Research Laboratory of the United States Steel Corporation, are briefly described and discussed. The changes may be best demonstrated by describing first the fresh dead-burned magnesia and then various types of material representing the refractories after they have been used in the furnace. The descriptions are based on microscopic examination of thin sections, polished surfaces and powder preparations, and on a few chemical analyses.

II. Dead-Burned Magnesia

The properties of magnesia refractories and the rocks from which they are made are well known from descriptions by numerous investigators.[1] The following general characteristics may be pointed out:

The carbonate rock, which is the raw material for dead-burned magnesia, usually consists of a more or less coarse-grained aggregate of well-crystallized minerals. (The so-called "amorphous magnesite" is also well crystallized, but only more fine grained than the usual varieties.) The main constituent is magnesite ($MgCO_3$), but the rock always contains variable amounts of other constituents such as lime- and ferrous oxide-bearing carbonates and some silicates.

When such a rock is heated to the temperature of dead burning, *i.e.*, to a temperature high enough for the complete decomposition of the carbonates and the melting of the silicates and iron oxide-bearing constituents, it will form a crystallized aggregate consisting largely of grains of periclase (crystallized MgO) imbedded in a matrix of silicates of the orthosilicate type, such as forsterite ($2MgO \cdot SiO_2$) and monticellite ($CaO \cdot$-

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February 14, 1934 (Refractories Division). Received April 19, 1934.

[1] For general descriptions and references see (*a*) J. Spotts McDowell and R. M. Howe, "Magnesite Refractories," *Jour. Amer. Ceram. Soc.*, **3**, 185–246 (1920); (*b*) G. M. Carrie and G. F. Pascoe, "Magnesite Refractories for Steel Furnaces," *Can. Mining Met. Bull.*, No. 186, pp. 1186–1272 (1927).

$MgO \cdot SiO_2$). Sometimes it will also contain a calcium ferrite ($2CaO \cdot Fe_2O_3$). A few observations on such dead-burned magnesia with reference to one of the standard varieties now on the market are given below.

The well-crystallized aggregate of the particular variety used as an example consists almost entirely of periclase and silicate (Figs. 1 and 2). The periclase occurs as rounded or indistinctly polygonal grains of a fairly uniform size, by far the greater part measuring between 0.02 and 0.04 millimeter in diameter. It has a slightly variable yellow to light brownish color in thin sections. The refractive index varies somewhat with the color, the average for the yellow grains being $n = 1.76$. This is higher than the index for pure crystallized MgO ($n = 1.734$), the higher index and the color no doubt being due to the presence of iron oxides, chiefly in the form of magnesioferrite ($MgO \cdot Fe_2O_3$), in solid solution in the periclase. Assuming that the entire admixture is magnesioferrite the periclase having a refractive index $n = 1.76$ should contain approximately 3% Fe_2O_3.[2] The silicate occurs in very small individuals and an exact determination of its optical properties is impossible. However, the properties that have been determined (biaxial positive, large $2V$, refractive indices varying between 1.63 and 1.67, moderately high birefringence) indicate that it has the composition of a fairly pure forsterite ($2MgO \cdot SiO_2$). According to the composition of the dead-burned magnesia (see Table I(A)) a lime-bearing silicate should also be present in the matrix, presumably in the form of monticellite ($CaO \cdot MgO \cdot SiO_2$), but since the refractive indices of this compound lie within the range of the indices for forsterite it is not possible to keep the two apart in the present fine-grained aggregate and no definite proof of the existence of monticellite in the silicate matrix can be given.

The structure of the dead-burned magnesia seems to be little influenced by the structure of the crude magnesite rock from which it is made or by the size of the fragments of the crushed rock as shown by the following facts: Samples of the crude magnesite vary considerably in structure; especially does the grain size vary from one sample to another or even from place to place within one little sample. In spite of these variations in the crude rock, numerous samples of the dead-burned magnesia examined under the microscope all show practically the same structure (grain size and fabric of the aggregates). The aggregates of periclase in the dead-burned magnesia are always much more fine grained than the aggregates of magnesite in the crude rock; in other words, each individual of magnesite gives rise to a number of individuals of periclase (see Fig. 1). The size of the periclase grains is evidently determined by the influence of the fluxes formed during the dead burning and not by the size of the original magnesite grains or by the size of the composite particles of the crushed rock.

III. New Open-Hearth Bottoms

The constitution of a new open-hearth bottom differs considerably from that of the dead-burned magnesia as will be shown by an example described below. The bottom is usually made by mixing the dead-burned magnesia with basic open-hearth slag and sintering the mixture layer by layer in the furnace till a thickness of 18 to 20 inches, measured from the magnesia brick base to the surface of the hearth, is reached. The total composition of the mixture may vary somewhat depending upon the compositions of the two materials used and their relative amounts. An example is given in Table I of a mixture, C, containing three parts of dead-burned magnesia, A, and one part of basic open-hearth slag, B.

[2] In using the refractive index as a basis for estimating the composition of this periclase and other varieties described in this paper it is assumed that when the index is plotted against composition it changes along a straight line from $n = 1.734$ for pure periclase to $n = 2.39$ for magnesioferrite (79.8% Fe_2O_3), and it is also assumed that no ferrous oxide is present in the periclase. These assumptions may not be strictly correct, but since exact data for intermediary compositions and for mixtures containing ferrous oxide are missing they give the closest approach to the true relations that can be obtained at present. The index for magnesioferrite is given by H. S. Roberts and H. E. Merwin, "The System MgO–FeO–Fe_2O_3 in Air at One Atmosphere," *Amer. Jour. Sci.*, **22**, 145–57 (1931). Some data showing the influence of ferrous oxide on the refractive index of periclase are given by H. G. Fisk and W. J. McCaughey, "Equilibrium Studies in Systems Containing Magnesium Oxide, Iron Oxide, and Magnesium Aluminate," *Ohio State Univ. Eng. Expt. Sta. Bull.*, No. 70 (July, 1932). These data show that the influence of a certain amount of iron on the refractive index of periclase is considerably less when the iron is present in the ferrous state than when it is present in the ferric state. When all the iron is assumed to be in the ferric state, therefore, the composition arrived at on the basis of the refractive index will give the minimum amount of iron present in solid solution in a periclase of the index determined. If an appreciable part of the iron is present in the ferrous state, the total amount is higher than estimated on the basis of the assumptions stated above.

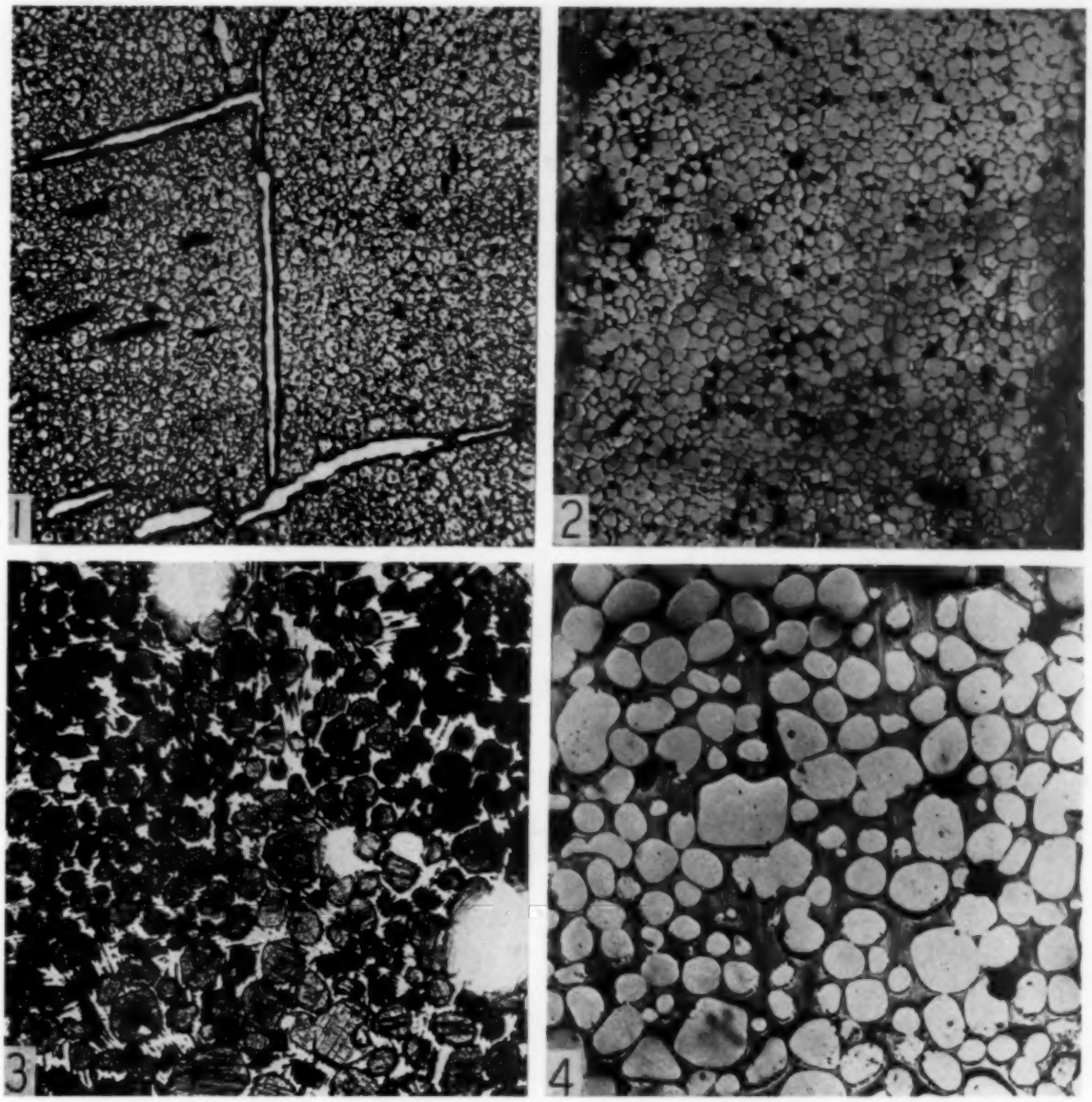

FIG. 1.—Dead-burned magnesia; thin section. Photomicrograph. ×66. A fine-grained aggregate of numerous rounded grains of periclase formed by decomposition of one large individual crystal of magnesite. The white stripes represent the cleavages of the original magnesite. The silicate matrix is not distinctly visible in this photograph (see Fig. 2).

FIG. 2.—Dead-burned magnesia; polished surface. Photomicrograph. ×94. Rounded white grains, periclase; narrow rims around the periclase grains, forsterite; black spots, pores.

FIG. 3.—Sample of new open-hearth bottom; thin section. Photomicrograph. ×66. Gray or black areas, periclase; white irregular areas, silicates; larger white areas, cavities.

FIG. 4.—Sample of new open-hearth bottom; polished surface. Photomicrograph. ×94. White spots, periclase; gray areas, silicates; black spots, cavities.

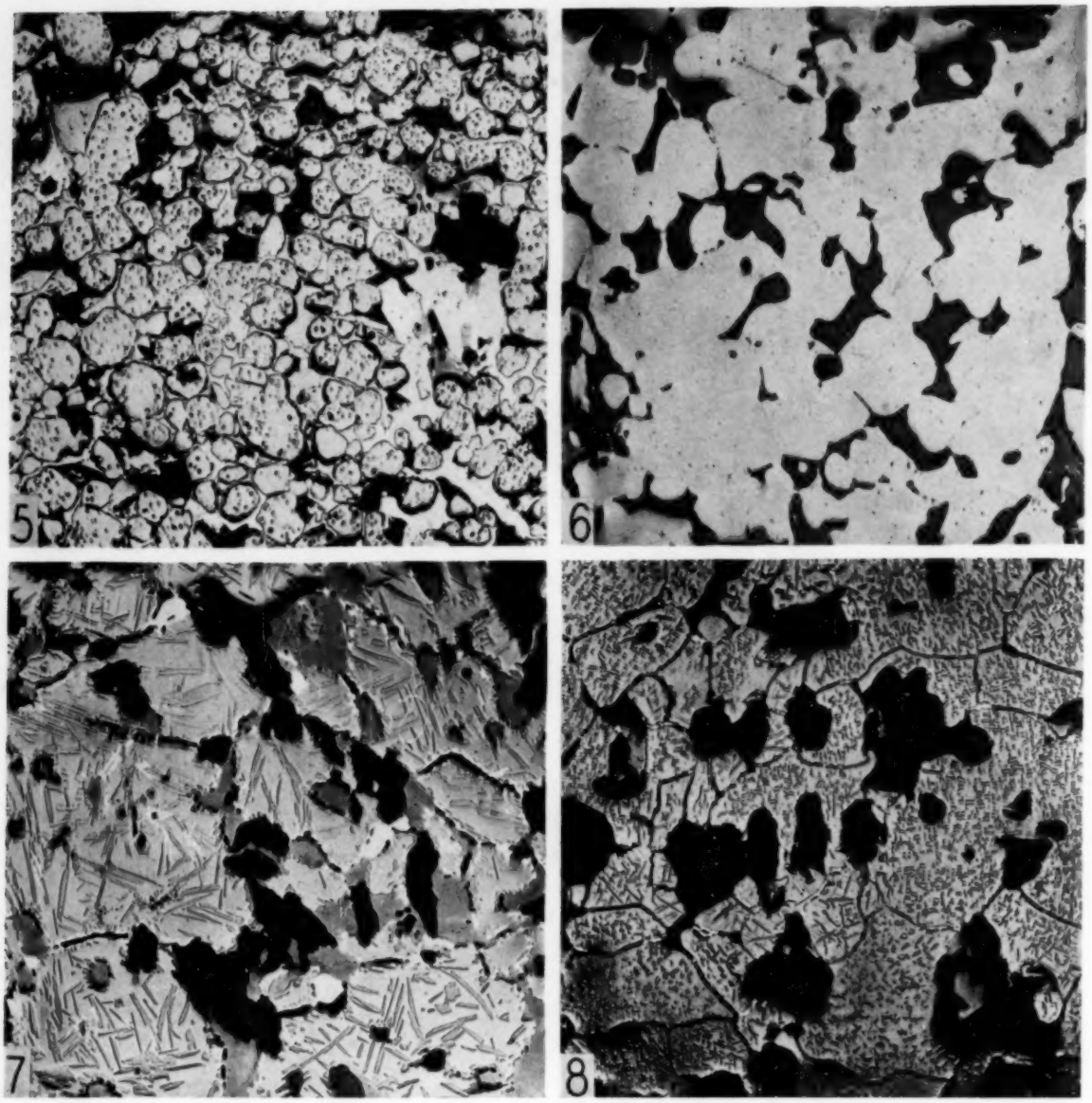

FIG. 5.—Sample of old open-hearth bottom, 15 to 17 inches below surface; polished surface. Photomicrograph. ×94. Rounded gray areas with small dark dots, periclase; irregular gray areas, silicates; white areas, ferrite; black spots, cavities.

FIG. 6.—Sample of old open-hearth bottom, 9 to 11 inches below surface; polished surface. Photomicrograph. ×94. White areas, periclase; gray areas, silicates; black spots, cavities.

FIG. 7.—Sample of old open-hearth bottom, 3 to 5 inches below surface; polished surface. Photomicrograph. ×94. Large light gray areas, periclase; slightly darker stripes (within periclase) and irregular areas, ferrite; dark gray areas, some with striation, silicates; white spots, metallic iron; black spots, cavities.

FIG. 8.—Sample of old open-hearth bottom at surface; polished surface. Photomicrograph. ×94. Large gray areas, periclase; small dots inside periclase, ferrite; black areas, cavities.

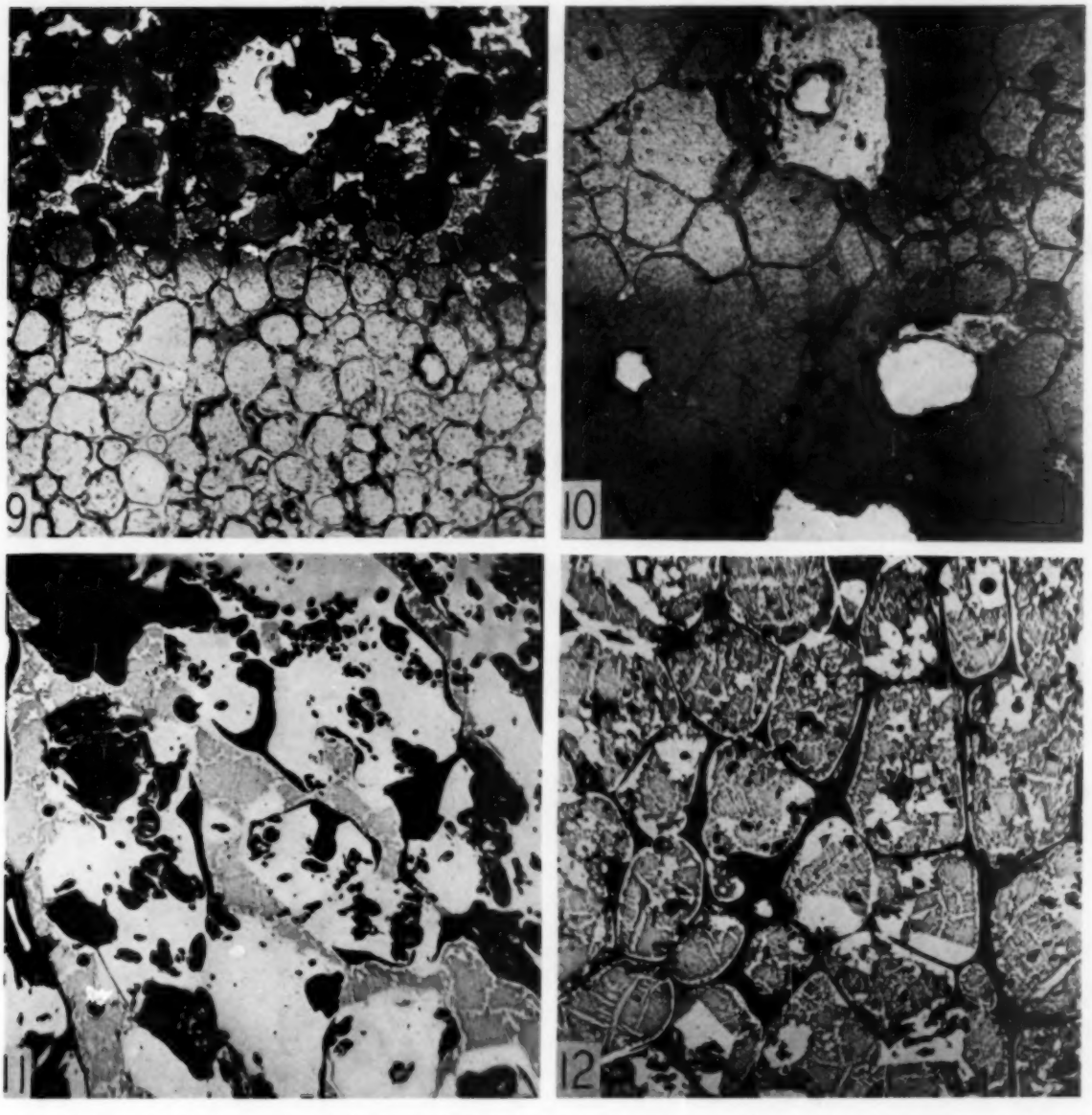

FIG. 9.—Sample of old open-hearth bottom, about 12 inches below surface; contact between light and dark parts of bottom; thin section. Photomicrograph. ×66. Dark part (top of photograph): rounded dark gray areas, periclase (dark variety); black irregular spots, ferrite; light gray areas, silicates. Light part (lower half of photograph): rounded gray areas, periclase (light variety); gray areas between periclase grains, silicates.

FIG. 10.—Sample of old open-hearth bottom, about 12 inches below surface: thin section. Photomicrograph. ×66. Gray, polygonal areas, periclase. (Note: variable darkness due to variation of iron content); light gray areas (a large one at top), silicates; white spots (bottom), cavities.

FIG. 11.—Layer of molten furnace dust on magnesia brick from end wall, near surface of layer; polished surface. Photomicrograph: oil immersion. ×210. White areas, magnetite; gray areas, magnesioferrite; large black areas, silicates; small black spots, cavities.

FIG. 12.—Layer of molten furnace dust on magnesia brick from end wall, a few millimeters below the surface of the layer; polished surface. Photomicrograph: oil immersion. ×210. White areas, magnetite; gray areas, magnesioferrite; large black areas, silicates; small black spots, cavities.

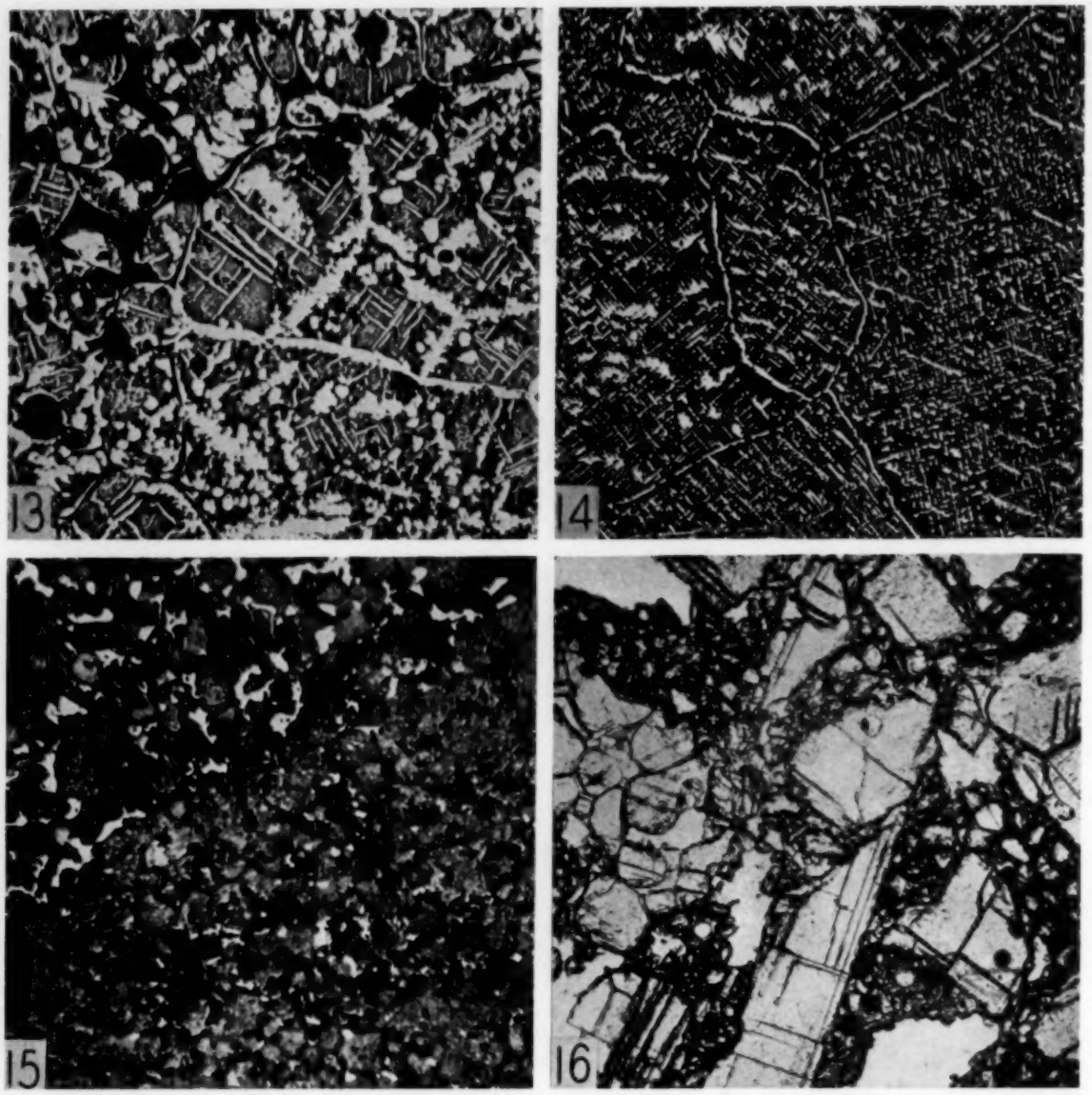

FIG. 13.—Layer of molten furnace dust on magnesia brick from end wall, somewhat below middle of layer; polished surface. Photomicrograph: oil immersion. ×210. White areas, magnetite; dark gray areas, magnesioferrite; irregular black areas, silicates; black circular spots, cavities.

FIG. 14.—Layer of molten furnace dust on magnesia brick from end wall, near bottom of layer; polished surface. Photomicrograph: oil immersion. ×210. Black areas, largely periclase–magnesioferrite solid solution (some silicates); white areas, magnetite.

FIG. 15.—Brown zone in magnesia brick from end wall, near contact with layer of molten furnace dust; polished surface. Photomicrograph: oil immersion. ×210. White spots, magnetite; gray areas, periclase; black areas, largely silicates.

FIG. 16.—Magnesia brick made of fused magnesia; thin section. Photomicrograph. ×57. White areas crossed by black lines, fragments of periclase showing cleavages; dark areas, mixture of silicates and small grains of periclase.

TABLE I

COMPOSITIONS (RECALCULATED TO 100%) OF MATERIALS USED FOR MAKING BASIC OPEN-HEARTH BOTTOM

	A	B	C
SiO_2	6.3	19.6	9.6
Al_2O_3	1.9	3.6	2.3
Fe_2O_3	3.9	7.7	4.9
FeO		18.6	4.7
MnO		8.5	2.1
MgO	82.5	6.9	63.6
CaO	5.4	33.7	12.5
P_2O_5		1.4	0.3
	100.0	100.0	100.0

A, dead-burned magnesia. B, basic open-hearth slag. C, mixture of three parts of magnesia, A, and one part of slag, B.

The following description of the constitution of a bottom of this composition is based on examination of samples collected from the bottom immediately before the first charge was put into the furnace.

The bottom consists essentially of periclase and two silicates (Figs. 3 and 4). The periclase forms rounded grains measuring from 0.02 to 0.2 millimeter in diameter (average about 0.08 millimeter). In thin sections it shows the usual cleavages and has a somewhat variable brownish red color. Its refractive index, $n = 1.81$ (average of several slightly variable values), indicates that it contains about 9% Fe_2O_3 (in the form of $MgO{\cdot}Fe_2O_3$) in solid solution. The silicates form a matrix around the grains of periclase. Their exact composition can not be given, but it seems certain that they both are of the orthosilicate type. One forms irregular, colorless or faintly yellow grains without distinct cleavages, has a refractive index β = approximately 1.655, a low birefringence, and is biaxial positive with moderately large $2V$. These properties are not far from those of monticellite ($CaO{\cdot}MgO{\cdot}SiO_2$) and the constituent may be assumed to have largely this composition with an admixture of other orthosilicates, such as ferromonticellite ($CaO{\cdot}FeO{\cdot}SiO_2$), in solid solution. This latter constituent is present in the slag mixed with the magnesia in the bottom sample here considered. The other silicate present in the matrix forms slender needles or lath-shaped crystals often imbedded in the monticellite. It has refractive indices α = approximately 1.705 and γ = approximately 1.725. Most of the crystals are apparently untwinned and have extinctions parallel to their elongation, some show polysynthetic twinning with the lamellae oriented across the elongation of the crystals and with extinction angles up to about 16°. A determination of the optical character has not been possible. This constituent may be a modification of the dicalcium silicate ($2CaO{\cdot}SiO_2$) containing other compounds in solid solution. A constituent of similar properties has been extracted from a sample of basic open-hearth slag and has been found by analysis to consist largely of $2CaO{\cdot}SiO_2$ with an appreciable amount of calcium phosphate (probably $3CaO{\cdot}P_2O_5$) and small amounts of silicates of magnesia, manganese, and ferrous oxide in solid solution. The constituent here considered is probably of a somewhat similar type. It should be emphasized that the optical properties of this constituent correspond more or less with those of the high-temperature (α or β) forms of the calcium orthosilicate and not at all with those of the low-temperature (γ) form. It may be assumed, therefore, that the solid solutions contained in this type of the calcium orthosilicate have prevented its inversion to the low-temperature form with the accompanying volume expansion and "dusting" at 675°C, and that the crystals thus have retained during the cooling the properties acquired when they crystallized at a higher temperature.

Comparing now the sample of a new open-hearth bottom just described with the sample of dead-burned magnesia described above, the following changes may be emphasized: The grains of periclase have grown in size, their average diameter in the bottom being two or three times the diameter of the grains in the dead-burned magnesia. At the same time the periclase has taken up iron oxide to such an extent that the grains in the bottom probably contain about three times as much Fe_2O_3 (9%) as those in the dead-burned magnesia (3%). These changes have been produced by the influence of the slag: Its action as a flux has caused the growth of the periclase crystals to relatively large individuals and its content of iron oxide has been the source of the increased iron oxide in the periclase.

IV. Old Open-Hearth Bottoms

Other stages in the changes of the magnesia refractories may be studied by examining samples from bottoms of furnaces that have been shut down after a long period of operation. De-

scriptions will be given in the following paragraphs of samples from a cross-section through such a bottom and of a few samples from another bottom.

(1) Cross-Section of Bottom The bottom had been made of materials like those described above and had been in use for over five years when the samples were taken. During this period the material in the bottom was exposed to the high temperature of the steel bath and to the chemical action of the bath and of the slag coming in contact with the bottom. Naturally this influence must have varied with the depth below the surface of the bottom and must have been greatest near the surface where the temperature has been highest and the chemical action presumably most intensive. This will be demonstrated by describing four samples from successively higher layers of the sintered bottom.

(1) A sample taken about 3 inches above the bed of magnesia brick on which the sintered bottom rests (15 to 17 inches below the surface) differs in several respects from the samples of a new bottom described above. The constituents are periclase, a calcium ferrite, and two silicates (Fig. 5). The periclase forms rounded grains up to 0.2 millimeter in diameter (average about 0.08 millimeter). It has a yellow color in thin sections. Its refractive index is approximately $n = 1.81$, indicating a content of iron oxide (Fe_2O_3) of about 9%. The ferrite forms a part of the matrix surrounding the grains of periclase and sometimes shows fairly well-developed lath-shaped crystals included in the silicates of the matrix. In thin sections it has a deep red-brown color and a faint pleochroism. Its refractive index can not be accurately determined but is approximately 2.3. These properties indicate a composition close to dicalcium ferrite ($2CaO \cdot Fe_2O_3$). The two silicates are of the same types as those described from the new bottom. Their distribution is somewhat irregular. Usually they form relatively thin films around the periclase grains, but sometimes they are gathered in larger patches.

(2) Another sample taken about 9 inches above the brick bed (9 to 11 inches below the surface) shows still greater deviations from the new bottom. Its constituents are again periclase, ferrite, and two silicates, but the ferrite is present in very small amounts (Fig. 6). The periclase no longer forms separate grains surrounded by a matrix of silicates; it occurs as a more or less continuous aggregate of grains with the grains of silicates interwoven in it or sometimes actually entrapped in the periclase. The individual crystals of periclase may measure up to 0.6 millimeter in diameter (average about 0.1 millimeter). In thin sections the periclase shows the usual cleavages and has a somewhat variable deep brown-red color. Its refractive index ($n = 2.0$) indicates a content of iron oxide of about 30%. The silicates have about the same properties as those of the previous sample. The high-index silicate (calcium-orthosilicate type) is predominating.

(3) A third sample was taken at a depth of about 15 inches above the brick bed (3 to 5 inches below the surface). It consists of periclase, ferrite, and two silicates and also contains some metallic iron (Fig. 7). The periclase forms polygonal grains up to 0.4 millimeter in diameter. In thin sections most of the grains have a deep blood-red color; some are nearly opaque. They show the usual cleavages. The refractive index is somewhat variable; the average value ($n = 2.17$) indicates that the periclase may contain about 50% Fe_2O_3. All the grains of periclase contain lamellae of ferrite in regular orientation as shown in Fig. 6. The same ferrite also occurs between the periclase grains. In thin sections it has a deep brownish red color and a faint pleochroism. Its refractive indices are approximately $\gamma = 2.33$, $\alpha = 2.25$ (for the red light transmitted through the immersion films of sulfur-selenium glasses). These properties would indicate a composition close to that of dicalcium ferrite ($2CaO \cdot Fe_2O_3$). When observed in reflected light on surfaces polished in the usual way the ferrite has a decidedly lower relief (lower hardness) than the periclase associated with it and a slightly lower power of reflection. Its reflection color is light gray with a faint olive tinge while that of the periclase is more of a neutral gray with an indication of a purplish tinge. The ferrite shows a weak anisotropic effect between crossed-nicols in reflected light. The silicates of this sample are essentially the same as those described above. They do not form a regular matrix around the grains of periclase, but are gathered in isolated aggregates more or less surrounded by the periclase, most of the periclase grains being joined together

without any appreciable amount of matrix between the grains.

(4) The fourth sample was taken at the surface of the bottom, 18 to 20 inches above the brick bed. Its constitution is much like that of the preceding sample. It consists of periclase, ferrite, two silicates, and a little metallic iron (Fig. 8). The periclase forms relatively large polygonal grains up to 0.5 millimeter in diameter, joined into a continuous aggregate intermixed with an aggregate consisting largely of silicates. In thin sections its color is deep brown-red and it shows the usual cleavages. Its refractive index is somewhat variable; the average value, n = approximately 2.1, indicates a content of about 40% Fe_2O_3. It contains numerous minute inclusions of a ferrite similar to that of sample 3. Some of the same kind of ferrite also occurs interstitially between the periclase grains. The silicates occur in mixed aggregates, often completely surrounded by periclase. The calcium orthosilicate sometimes occurs in fairly large grains showing polysynthetic twinning which may be observed both in thin sections and polished surfaces.

(2) Scattered Samples from Old Bottom

The samples now to be described represent a bottom made of the same kind of materials as the bottoms considered above. They were collected at depths of 9 to 12 inches below the surface after the bottom had been in use for 366 heats. They are chosen as examples chiefly to demonstrate a feature that seems to be quite common in basic open-hearth bottoms, namely, the occurrence of two distinctly different varieties of periclase, one dark (high in iron oxide) and one light (low in iron oxide) in adjoining parts of the bottom.

The two kinds of periclase occur in separate aggregates which are distributed in a rather irregular way in the bottom, and since the periclase to a large extent determines the color of the aggregate in which it occurs, the bottom samples appear to the naked eye as a mixture of dark (almost black) and light grayish brown parts. Sometimes the dark parts form actual veins penetrating the light parts; in other cases they form very irregular bodies of variable size surrounded by the light parts.

The dark parts (see Fig. 9) consist of periclase, ferrite, and the usual mixture of two silicates. Fluorite (CaF_2), in small amounts, occurs in some of the samples and a trace of apatite ($3(3CaO \cdot P_2O_5)CaF_2$) has also been observed. The periclase may form separate grains, measuring up to 0.3 millimeter in diameter, surrounded by a matrix of silicates and ferrite, but it may also form larger individuals, up to 1 millimeter in diameter, joined to more or less continuous aggregates, while the silicates form separate aggregates interpenetrating the periclase aggregates or being enclosed by them. The periclase shows the usual cleavages in thin sections, and its color in transmitted light is deep blood red. Its refractive index varies between 2.0 and 2.1 indicating a content of iron oxide of 30 to 40%. The ferrite usually forms irregular grains interstitial between the periclase grains; sometimes it is seen as well-developed crystals in cavities where it is associated with aggregates of silicates and fluorite. These crystals are tabular with rhombic outlines (lath-shaped in cross-sections) and have a deep red-brown color in transmitted light. They are biaxial positive with small $2V$, γ perpendicular to the plates, plane of the optic axes bisecting the obtuse angle (of about 92°) between the edges of the rhombic plates. The refractive indices are approximately γ = 2.25, α = 2.15. These properties agree fairly well with those of dicalcium ferrite. In some of the samples the ferrite forms oriented lamellar inclusions in periclase exactly like those described above (sample 3 of the cross-section of an old bottom). The silicates are not essentially different from those of the other samples. Sometimes the calcium orthosilicate forms fairly well-developed spear-shaped crystals included in the other silicate and showing distinct twinning.

The light parts of the samples consist of periclase and two silicates, and contain no ferrite (Figs. 9 and 10). The periclase forms rounded separated grains up to 0.3 millimeter in diameter enclosed in a matrix of silicates. Its refractive index, n = approximately 1.76, would indicate a content of about 3% Fe_2O_3 if all the iron were in the ferric state. However, the light color of the periclase grains shows that a considerable part of the iron must be present in the ferrous state and the total amount of iron corresponding to the refractive index 1.76 is then larger than 3% (figured as Fe_2O_3). The silicates appear to be essentially of the same type as in the previous examples. They usually form narrow rims of

interstitial aggregates around the grains of periclase, but may also occur in larger aggregates surrounded by periclase.

The transition from the dark to the light parts is very sharp (see Fig. 9). The periclase may pass from a light variety containing a relatively small amount of Fe_2O_3 to a dark variety containing perhaps 30% Fe_2O_3 within one individual crystal grain no more than 0.1 millimeter in diameter, one side of the crystal being dark and the other side light. The change in the constitution of the matrix between the periclase grains is also complete within a narrow zone.

The light parts of these aggregates may have been formed under the influence of reducing gases given off by the molten metal and penetrating downward into the bottom. The effect of such a reduction on the periclase is a change of its color in transmitted light from red to light yellowish green and a lowering of its refractive index, caused by the change of a considerable portion of the iron oxide from ferric to ferrous. Apart from this reduction of the iron oxide the light parts do not seem to be essentially different from the aggregates of a new bottom like those described in a previous section of this paper.

The dark parts have no doubt been formed by introduction of considerable amounts of iron oxides, largely ferric, into the original bottom. A large portion of this oxide has been absorbed by the periclase which has remained in the solid state, the iron oxide diffusing into it to form a solid solution of periclase and magnesioferrite. The matrix around the periclase crystals, on the other hand, must have been at least partly remelted and it has recrystallized to a new aggregate in which the calcium ferrite is an added constituent. This change in the original bottom must have been produced by a slag of such high fluidity that it could easily penetrate through narrow openings to the lower levels of the sintered bottom. Whether the average open-hearth slag would have such properties can not be said for certain. The slag in its most viscous state would probably not be able to penetrate far into the bottom, but in its more fluid state, when it is high in iron oxides and lime and when it may have been "thinned" by addition of fluorite, it would no doubt have all the properties necessary to produce the changes described.

(3) Summary of Features of Old Bottoms

The examples described represent a small selection among numerous samples of old bottoms, but they are believed to be typical, and a description of additional examples would not change the picture of the main features of the constitutions characterizing these bottoms.

The changes in the upper layers of the bottom during the operation of the furnace are brought out clearly by comparing the constitutions of the new and the old bottoms. It has been shown that the content of iron oxide in the periclase may increase from 9% Fe_2O_3 in a new bottom to as much as 50% Fe_2O_3 in an old bottom. Simultaneously with this change in composition the periclase grains grow in size and gradually coalesce so as to form an aggregate which approaches the state of a continuous body of a rigid refractory with liquid silicates (and calcium ferrite) interspersed in it. Otherwise expressed the top layer of the sintered bottom tends to change from the state of a "crystal mush" consisting of globules of solid periclase suspended in a liquid slag to the state of a "monolithic" body of periclase containing inclusions of liquid slag.

These changes in the upper layers have no doubt been produced by slag coming in contact with the bottom. The composition of the slag changes during the heat. At the beginning of a heat, before the addition of hot metal and before any large amount of the scrap iron is melted, the slag is very high in iron oxide and lime. This slag comes in direct contact with a considerable part of the bottom and, since it is very fluid, it may also find its way through pores and cracks to the deeper layers of the bottom. As the heat proceeds the slag becomes gradually higher in silica and lower in iron oxide and this later slag remains separated from the bottom by the continuous layer of molten metal now present in the furnace. Thus the change in the upper layers of the bottom must be due largely to the influence of the early slags of successive heats.

The heterogeneous mixture of dark and light aggregates observed at the deeper layers of many bottoms is explained as follows: Very fluid slags rich in iron oxide and lime have trickled down from the hearth through cracks and pores in the sintered bottom and have introduced a large

amount of iron oxide into the periclase (low in iron oxide) of the original bottom and have also caused the crystallization of a considerable amount of calcium ferrite in the matrix between the periclase grains. This change has taken place without melting the periclase, but with a considerable amount of remelting and subsequent recrystallization of the matrix surrounding the periclase grains. The final result is the formation of the dark aggregates of the bottom, these aggregates having much in common with the surface aggregates of old bottoms discussed above. The light aggregates may have been formed under the influence of reducing gases given off from the molten metal in the hearth. By reducing to ferrous oxide a considerable portion of the ferric oxide contained in the periclase, these gases have "bleached" the periclase and thus produced the light color of the aggregates.

V. Melting of Magnesia Brick in End Walls

Magnesia materials, occasionally used in the end walls of open-hearth furnaces, react in a characteristic way with the furnace dust, consisting largely of iron oxides, that is impinging upon them during the operation of the furnace. These reactions have been studied on samples collected from an open-hearth end wall built of a high-grade magnesia brick and exposed to the dust-carrying flames of the furnace for a long time.

The samples represent the inner side of the wall and consist of pieces of magnesia brick covered with a black layer formed by crystallization of the once molten furnace dust attached to the brick. The brick itself has a light brown color and consists largely of an aggregate of fine and coarse fragments of nearly pure periclase (fused magnesia) cemented together by a matrix of silicates (see Fig. 16). Between this unaltered brick and the black oxide layer there is a dark brown zone about 5 millimeters wide passing rather abruptly over into the black layer and more gradually into the fresh brick. The oxide layer has a grayish black color and a metallic luster; it is very hard and strongly magnetic. Its thickness varies from a few millimeters up to many centimeters. It contains a number of cavities, evidently formed by escaping gases. These two parts of the samples, the black layer and the brown zone, will now be described.

(1) Black Layer The microscopic examination shows that the black layer is a heterogeneous aggregate consisting chiefly of magnesioferrite and magnetite and small amounts of forsterite. The exact compositions of these phases can not be determined. The phase called magnesioferrite varies from one part of the layer to another as will be described below. It may be assumed to represent solid solutions (or submicroscopic mixtures) either of MgO with large amounts of $MgO{\cdot}Fe_2O_3$ or of $MgO{\cdot}Fe_2O_3$ with some Fe_3O_4. Otherwise stated its composition may be expressed by variable amounts of MgO, Fe_2O_3, and FeO with the compound $MgO{\cdot}Fe_2O_3$ predominating. The magnetite is probably also a somewhat variable solid solution (or submicroscopic mixture) containing some $MgO{\cdot}Fe_2O_3$ and perhaps some excess FeO, but with the compound Fe_3O_4 predominating. The forsterite is largely $2MgO{\cdot}SiO_2$, but it no doubt contains small amounts of other orthosilicates in solid solution and there may be individual phases of other silicates mixed with it.

The layer shows no definite trace of the structure of the original brick. This proves that the mixture of the materials of the furnace dust and the magnesia brick from which it is formed must have been largely, if not completely, molten when the crystallization took place.

TABLE II
ANALYSES OF CORRODED MAGNESIA BRICK

	A	B
SiO_2	1.89	
Al_2O_3	1.71	
Fe_2O_3	64.34	31.25
FeO	14.56	15.05
MgO	14.25	43.01
CaO	3.03	
	99.78	
Insoluble	2.47	3.56

A, black layer B, brown zone
Analyst: Elizabeth Keedick Lee

An analysis of an average sample of this layer is given in Table II (A). A recalculation of this analysis in terms of actual phases can not be undertaken because the exact compositions of the phases are not known, but it is easily seen that if the composition is expressed in compounds, the main constituents are $MgO{\cdot}Fe_2O_3$ and Fe_3O_4 and that there are small amounts of silicates and probably some spinel and calcium ferrite present. The analysis does not, however, represent the actual composition throughout the

black layer because the composition as well as the structure change gradually from the exposed surface toward the contact with the brown zone as the microscopic examination shows. This will be demonstrated by describing the microstructures at four different levels of a sample of the black layer.

(1) Near the surface magnetite is the dominating constituent, magnesioferrite and forsterite forming the matrix between the magnetite crystals. This aggregate is shown in Fig. 11. The magnesioferrite is here of a type containing magnetite either in solid solution or as submicroscopic inclusions. The presence of this invisible magnetite is indicated by the fact that the magnesioferrite is perfectly opaque in thin sections, has a relatively strong reflecting power, and consequently shows a light gray color in polished sections. The visible magnetite at this place occurs in rather large grains up to 0.3 millimeter in diameter, often showing distinct crystal outlines against magnesioferrite and forsterite. At the surface of the black layer a few thin lamellae of hematite are occasionally seen.

(2) At a short distance, say 1 to 3 millimeters, from the surface the aggregate has the appearance illustrated in Fig. 12. It consists of rounded or polygonal grains of magnesioferrite imbedded in a matrix of forsterite and containing numerous inclusions of magnetite. The magnetite also forms narrow rims along the edges of the magnesioferrite grains. The magnesioferrite is a variety similar to that of the surface part of the layer, containing a considerable amount of invisible magnetite although probably less than the magnesioferrite of the surface aggregate. The total amount of magnetite in this aggregate (2) is evidently less than in the surface aggregate.

(3) At a distance of from 2 to 5 millimeters from the surface the aggregate is the one shown in Fig. 13. It has much in common with the aggregate from level (2) consisting of grains of magnesioferrite imbedded in a matrix of forsterite and containing inclusions and borders of magnetite. In this aggregate, however, the magnesioferrite contains still less invisible magnetite than in aggregate (2). Another difference is that the visible inclusions of magnetite are more distinctly lamellar in aggregate (3) than in (2).

(4) The innermost part of the black layer consists almost exclusively of magnesioferrite and magnetite, forming an aggregate illustrated in Fig. 14. The magnesioferrite forms large individual grains with thin borders and numerous lamellar inclusions of magnetite. Judging from its relatively dark gray reflection color in polished surfaces it contains little if any invisible magnetite. Very small amounts of interstitial forsterite are scattered between the grains of magnesioferrite.

(2) Brown Zone The brown zone along the boundary between the black layer and the brick is characterized by large amounts of periclase in association with somewhat smaller amounts of magnetite and some forsterite. A partial analysis of an average sample of this zone is given in Table II(B). Although an accurate recalculation of this analysis is impossible the figures show that there must be a considerable amount of magnesioferrite present in the aggregate, and since no separate magnesioferrite phase is seen under the microscope this compound must form solid solutions (or submicroscopic inclusions) in the periclase. The magnetite may contain magnesioferrite and some excess FeO in solid solution (or as submicroscopic inclusions).

The composition of the part next to the black layer is probably not much different from that of the innermost part of the black layer itself. This part contains large amounts of a periclase high in magnesioferrite (perhaps up to 40 to 50%). In the periclase there are numerous small skeleton inclusions of magnetite which render it opaque in thin sections. Magnetite also occurs in the matrix binding the periclase grains together, the main constituents of this matrix being the usual silicates (largely forsterite).

Farther away from the black layer the periclase of the brown zone becomes transparent in thin sections with brown colors and generally lighter the farther from the contact. This is due to a gradual decrease in the amount of magnesioferrite. At the same time the amount of magnetite inclusions in the periclase also decreases rapidly while the interstitial magnetite is more persistent. Figure 15 is a photomicrograph from this part of the brown zone. The constitution of this part is not materially different from that of the unaltered magnesia brick.

(3) Discussion of Reactions The constitution and structure of the black layer and the brown zone may be

interpreted on the basis of the equilibrium diagram of the system $MgO–FeO–Fe_2O_3$ published by Roberts and Merwin (see footnote 2).

The results of Roberts and Merwin, as far as they have any bearing on the problems dealt with in this paper, may be summarized as follows: Their investigations cover compositions in the neighborhood of the line $MgO–Fe_2O_3$ in the ternary diagram $MgO–FeO–Fe_2O_3$ and include some compositions within the partial diagram $MgO·Fe_2O_3–Fe_3O_4–Fe_2O_3$. They have been restricted to temperatures between 1000°C and 1800°C and to a constant oxygen pressure of about $^1/_5$ atmosphere (atmospheric conditions). The results include determination of the initial melting temperatures (solidus surface) for a number of compositions, but not determination of the final melting temperatures (liquidus surface). The greater part of the results, however, concern the behavior of the mixtures in the solid state. Magnesioferrite, $MgO·Fe_2O_3$, the only magnesia compound known in the system, dissociates slightly on heating and begins to melt at about 1750°C. At high temperatures it forms a continuous series of solid solutions with magnetite, Fe_3O_4, but these solutions unmix on cooling, forming phases the exact nature of which has not been determined. The temperature of unmixing varies with the composition; it rises from the $MgO·Fe_2O_3$ point toward the iron-oxide side of the diagram, where it is 1386°C. Another series of solid solutions extends along the $MgO–Fe_2O_3$ line from MgO to a point representing about 73% Fe_2O_3 and out into the ternary field toward FeO. These solid solutions also unmix on cooling. The temperatures of unmixing rise from near 1000° at the composition MgO to about 1770° at 73% Fe_2O_3. The exact nature of the phases formed by unmixing has not been determined. The magnesioferrite seems to be able to hold in solid solution small amounts (about 1%) of MgO at all temperatures below melting. The curve of initial melting (solidus curve) of the solid solutions of magnesioferrite and magnetite is shown in the diagram. It passes through a maximum at a composition (about 83% Fe_2O_3) not far from magnesioferrite (79.8% Fe_2O_3) at a temperature of 1770° and ends near Fe_3O_4 at 1582°C.

In applying these data of the equilibrium diagram to the interpretation of the reactions in the end wall, certain conditions obtaining in the furnace should be noted:

The flow of air and fuel* passing through the furnace is reversed at regular intervals of 10 to 15 minutes. During one of the periods, the hot dust-carrying flames strike against one of the end walls depositing the dust and bringing the temperature gradually up to perhaps 1600 to 1650°C at the inside surface of the wall. During the next period the flames will strike in the same way against the other end wall while the inside surface of the first wall will cool down to possibly about 1400°C, no appreciable amount of dust now being deposited on that wall. Thus the conditions at the inside surface of an end wall alternate between a high-temperature stage with deposition of molten dust and a stage of somewhat lower temperature without deposition of dust.

The hot mixture of gases striking against the end wall during the high-temperature period has lost the greater part of its free oxygen during the combustion in the furnace chamber. The atmosphere in contact with the molten surface layer of the end wall during this period, therefore, has a low oxygen pressure and tends to establish equilibrium with an oxide mixture relatively high in FeO and low in Fe_2O_3. During the next period, on the other hand, the incoming air now passing by the end wall has the oxygen pressure of the atmosphere and the oxide mixture consequently tends to become higher in Fe_2O_3 and lower in FeO. In other words the surface layer on the end wall will be exposed to an atmosphere which is alternately reducing and oxidizing. The oxidizing (low-temperature) stage corresponds to the conditions of the equilibrium diagram of Roberts and Merwin and for this stage the data of the diagram can be applied without modification as far as the ratio $FeO:Fe_2O_3$ is concerned. During the reducing (high-temperature) stage, on the other hand, the iron-bearing phases formed in the end wall will be higher in FeO and correspondingly lower in Fe_2O_3 than the phases formed in air under otherwise equal circumstances and therefore the data of the equilibrium diagram can not be directly applied to that stage.

* The fuels used in the furnace from which the samples were taken were oil and tar. The fuel is not preheated and does not come in contact with the end wall before entering the furnace chamber. Therefore, the oxygen pressure of the incoming air is not reduced by this fuel.

It should also be pointed out that the materials in the end wall are not pure magnesia-iron oxide mixtures but contain other components, largely in the form of silicates. The most important effect of these components will be to lower the melting temperatures of the magnesia-iron oxide bearing phases.

Bearing in mind the modifying conditions just indicated, the data of the equilibrium diagram may now be applied to the reactions in the end wall.

It seems clear that no direct melting of the relatively pure periclase (MgO) in the magnesia brick takes place at the temperatures reached in the end wall. Before any essential part of the magnesia can be removed from the brick in a molten state the magnesia must take up a large amount of iron oxides in solid solution. The ferric oxide combines with magnesia to form magnesioferrite ($MgO \cdot Fe_2O_3$) and between this compound and periclase there is, at high temperatures, an almost continuous series of solid solutions (from pure MgO to 73% Fe_2O_3). At the same time the periclase also takes up ferrous oxide (or magnetite) in solid solution. The combined effect of these solid solutions is to lower the melting temperature of the magnesia-bearing phase (the original periclase) very considerably. Under the conditions represented in the equilibrium diagram the lowest temperature reached by the initial melting curve (solidus) of these solid solutions is about 1750°C which is higher than any temperature ever obtaining in the end wall. Under such conditions, therefore, no melting of the periclase-magnesioferrite solid solution would take place. In the end wall, however, the relatively high amount of ferrous oxide present in the solid solution will no doubt lower the melting temperature to a point below that obtaining during the high-temperature period of the end wall (when also the ferrous oxide reaches its maximum). The silicates contained in the brick and in the molten dust will have an influence in the same direction as pointed out before. Thus there is hardly any doubt that the gradual erosion of the brick is caused not by a direct melting of the original periclase but by the melting of a solid solution of periclase and large amounts of iron oxides or a solid solution of magnesioferrite and magnetite.

The reactions producing this melting of the magnesia-bearing solid solutions take place at the contact between the molten black layer and the solid periclase of the brown zone. In the parts of the brown zone next to the contact, the solid solution is just approaching a composition which will enable it to melt at the temperature of the end wall. At some distance from the contact the periclase is still too low in iron oxides for any melting, so much the more so as the temperature is also lower than at the contact. Thus the melting proceeds as fast as the periclase of the brown zone can absorb enough iron oxides to become fusible.

While this absorption of iron oxides goes on in the brown zone the black layer is at least partially and periodically in a liquid state. It is evident from the microscopic observations, however, that it does not form a homogeneous melt or uniform mixture. It becomes gradually higher in iron oxides, especially ferric oxide, and lower in magnesia toward its exposed surface. The reason for this must be that the diffusion in the layer has not been sufficiently rapid to equalize the difference in composition between the two boundary faces of the layer caused by addition of iron oxides at the exposed surface and addition of magnesia (and loss of iron oxides) at the contact with the brown zone. Therefore, when the final cooling has taken place the constitution of the layer will vary from the surface inward as shown in the description of the microstructures.

The equilibrium diagram offers an explanation of the lamellar structure shown by the magnesia-bearing phases of all parts of the black layer except a narrow zone next to the surface (see descriptions and Figs. 11 to 14). It is reasonable to assume that all the aggregates of the black layer were formed with homogeneous solid solutions as principal constituents. This would represent the state of equilibrium at high temperatures according to the diagram. At lower temperatures the homogeneous phases would unmix; one of the phases formed by unmixing would have a composition close to that of magnetite and this phase would precipitate inside the crystals of the other phase and would form the oriented lamellae characteristic of such unmixings, as shown in the examples described. Thus the lamellar structure may be explained as due to unmixing in the solid state of the homogeneous solid solutions formed by the crystallization of the interior parts of the black layer.

In the surface part of the layer (see Fig. 11) unmixed phases may not have formed because the original phases crystallizing from the melt did not represent saturated solid solutions at the moment they crystallized and therefore may not have become supersaturated at lower temperatures. The lamellae of hematite, occasionally seen at the surface of the layer but never in its interior parts, may be explained as due to oxidation of the thin film most immediately exposed to the air during the cooling.

From what is stated above it is clear that the rate at which the magnesia is carried away in the molten state is influenced by several factors. It depends upon how fast the low-melting solid solution of periclase and iron oxides can form, and this again depends upon the rate of diffusion of the iron oxides from the molten oxide layer into the solid periclase and upon the area of the contact surface between the oxide layer and the periclase. It is obvious that under otherwise equal circumstances the rate will be higher the more porous the brick is. Naturally the rate increases with rising temperature. During the high-temperature period of the end wall it may be fairly high while during the low-temperature period there may be no melting at all but rather crystallization of the melt formed during the high-temperature period. At the same time the periodic changes in the oxygen pressure of the atmosphere in contact with the end wall, coinciding with the changes in temperature, will affect the melting of the iron oxide-bearing solid solutions in the same directions as the temperature changes. The solid solutions formed during the oxidizing conditions of the low-temperature period will have higher melting temperatures than those formed during the relatively reducing conditions of the high-temperature period. Thus low porosity, low temperature, and an oxidizing atmosphere would seem to be the main conditions favoring a high resistance of the brick toward destruction by melting under the influence of the layer of furnace dust deposited on it.

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RESEARCH LABORATORY
UNITED STATES STEEL CORPORATION
KEARNY, N. J.

CORRELATION OF VISCOSITY MEASUREMENTS WITH FLOW OF GLASS*

BY H. K. RICHARDSON

ABSTRACT

The following paper describes the transformation from the rule-of-thumb state to a scientifically controlled process of the filling of the glass insulation into the brass shells for incandescent lamp bases. It is divided into three parts: (*a*) the development of the platinum alloy dies or orifices, (*b*) determination of the flow of glass through the platinum dies or orifices, and (*c*) automatic control of glass-stream temperature by means of radiation pyrometers.

For three decades or more this process has been in operation. Wonderful strides have taken place in the development of the machinery needed until at present the medium screw base (No. 102) for general home lighting is filled with glass and the glass is shaped at the rate of 220 per minute. Actually 12,000 bases are processed per hour by this machine, which is known as a glass base machine.

In brief, the process consists of indexing a brass shell and eyelet held in a proper holder under a flowing stream of glass, cutting the stream, pressing the glass into shape, cleaning the glass from the eyelet holes, and blowing the hot base off into an annealer for cooling.

Control of the glass stream lagged woefully behind the development of the machines and represented a strictly rule-of-thumb handling. The crux of the difficulty was the constantly varying size of the orifice through which the glass is delivered to the glass base machine. A porcelain die was used for this purpose and quickly enlarged due to erosion.

The development of a platinum alloy-lined refractory die solved the problem of the varying size of the orifice. While this development was being carried on, the field of automatic control for the oil-fired tank was kept continually in mind and various promising installations were experimented with. Thus when the unvarying orifice was developed, the whole process of control was immediately available.

The present status of this work as here described does not represent a perfect solution but only the present situation which is subject to further improvement.

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A. DEVELOPMENT OF THE PLATINUM ALLOY-LINED DIE: THE DIE OF UNVARYING DIAMETER

By H. K. Richardson

I. The Problem

In the original process for flowing glass to the bases, a porcelain die or orifice was used. These dies began to enlarge from erosion almost as soon as the stream started to flow. It was customary to start a new die with a small hole and a hot stream. Full machine speed was not obtained until thirty-six to forty-eight hours of running. After seventy hours of use, the hole was too large so it was reduced by means of a tapered plug into which a groove was ground. This plug, set into the mouth of the die when rotated, served as a valve to obtain the required flow of glass. The groove in the plug in turn eroded and required replacement. Thus, the flow of glass was continually changing and the furnace was being interrupted at irregular intervals for replugging. Under these conditions the operation of such a furnace was an art and called for long experience. It was customary to adjust the delivery of glass by changing the temperature of the glass or by doctoring the glass batch with sand or soda. Such corrections naturally stored up trouble, for the glass composition sooner or later became unstable and fractured glass increased enormously. The final result was a periodic complete disruption of the operation for varying lengths of time until a complete new start could be made.

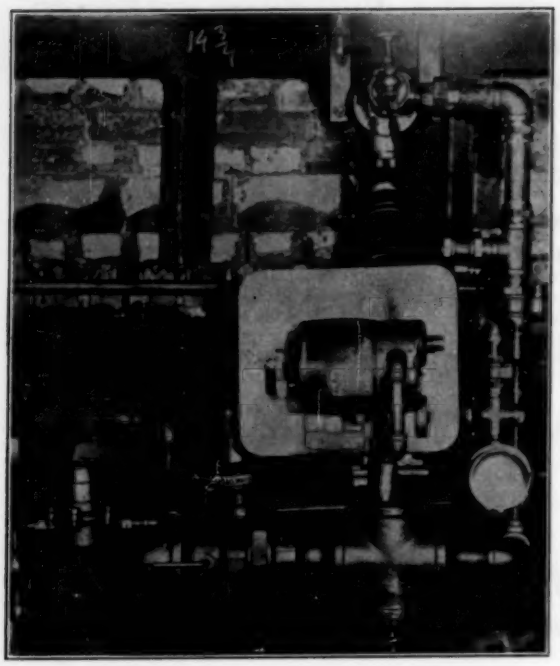
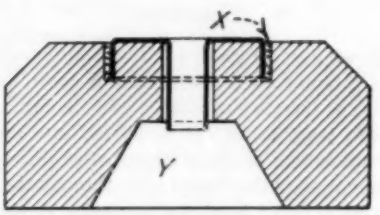


Fig. 1.—View of automatic control burner; Minneapolis-Honeywell; proportionating valve is behind the shield.

Every two weeks the worn-out porcelain die was removed from the furnace and replaced. To take full advantage of the improvement in machines, scientific control of the glass stream was a necessity. The prerequisite for such control was an orifice of unvarying size. Dies made from high-temperature alloy metal and various refractory compositions were found to be no better than the porcelain ordinarily used.

II. Solution of the Problem

After many attempts a platinum alloy-lined refractory die has been developed which overcomes most of the troubles. An alloy of 10% rhodium and 90% platinum is the best material to resist the abrasive action of the flowing glass stream. A liner made of this material, 0.030 inch thick, inserted into an Alundum refractory support is now the accepted die. The construction of this liner and its support is evident from Fig. 2. Ten of these dies are now in active service (life up to 4300 hours) and have proved satisfactory.



Assembly of parts shown above

Fig. 2.

III. Results Obtained

To evaluate the advantages obtained from the alloy liner, the results from a die the shape of

Fig. 6 are tabulated with the comparative data from an old porcelain die.

	Alloy liner No. 4 (Fig. 6)	Old porcelain die
No. of hours glass flowing through die without loss or abrasion	Still in use	
	3250	Under 15
No. of bases filled (before enlargement)	Does not enlarge	About 50,000
No. of bases filled (before plugging)	Never plugged	About 200,000
No. of bases filled (during life)	38,000,000+	1,881,875 av.
No. of plugs during life	None	3.5 av.
No. of interruptions of furnace due to plugging	None	10
No. of bases per Alundum base	6,000,000*	
No. of bases per porcelain die		1,881,875
Increased production per hour over porcelain die	7–15%	

* Doubled by new shape Fig. 2.

IV. Peculiarities and Precautions

(1) Foreign Metals As is well known, base metals alloy quickly with platinum. One insert was ruined after 1500 hours of service through metallic brass getting into the glass. No ill effect has been found from the presence of 1.5% PbO in the glass used.

(2) Starting a Die It is difficult to start the glass flowing through a new die until the whole surface is wetted. After the flow starts, a few hours' run is needed to get full delivery. No evidence has ever been found of a permanent set or expansion of the tube to answer this question. The insert once broken in always gives the same delivery no matter how often it is changed to a new refractory support.

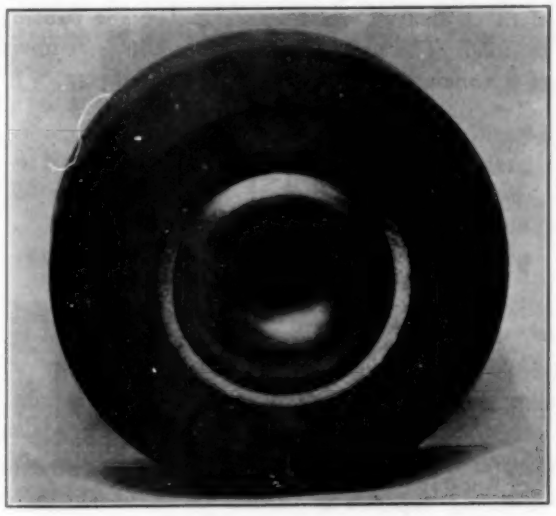


FIG. 3.

V. History of Development

For this investigation only production furnaces were available and as no interruptions to production could be tolerated only gradual changes in die shapes could be made. Since the life of a die had to be long to be economical this development spread over a long period.

To date thirty platinum liners have been made up. Of these, ten are still in use. The remainder have been turned back for credit on new dies as changes have been made.

(1) Die No. 1 The first insert made of pure platinum followed the contour of the original porcelain die. The whole insert was spun out of a single sheet. A regular porcelain die was used as the base. It was turned out with a diamond point to allow an 0.010-inch clearance for the insert. The contour of the working surface of the insert corresponded exactly to that of the porcelain dies then in daily use. Figures 3 and 4 show this construction in detail. This insert 0.015 inch thick lasted approximately 500 hours. Failure was caused by the insert breaking up in the lower end of the funnel at *F*, Fig. 4. Examination of the break showed the platinum to have crystallized and parted from lack of strength. Very little trace of impurities of any kind was found.

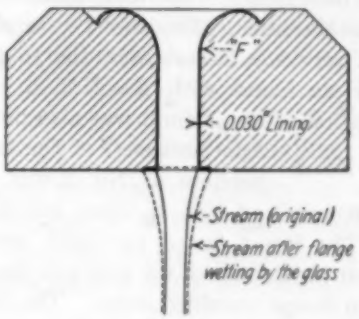


FIG. 4.

While using this die a sudden increase in delivery of glass was encountered. Investigation indicated that the insert was intact but the stream had wetted the collar on the exit end and was flowing from the outer edge, thereby increasing the effective area of the stream. This situation is illustrated in the dotted section of the stream flow in Fig. 4. This difficulty was cured by bolting an

extension flange to the bottom of the liner so that a thin discharge edge was formed $^3/_{16}$ inch below the refractory (see Fig. 5).

(2) Die No. 2 An insert of similar shape to die No. 1 with the extended flange made of 90% platinum and 10% iridium was tried next (see Fig. 5). The flange was

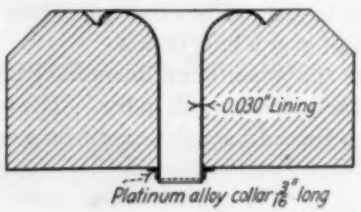


FIG. 5.

crimped onto the tube. In this insert the thickness was increased to 0.025 inch; otherwise everything was the same. This insert gave about 800 hours of service. Failure was due to the same difficulty as found with die No. 1. A slight volatilization of the iridium was also noted.

(3) Die No. 3 Another insert of the same proportions as No. 2 was made of 90% platinum and 10% rhodium but 0.030 inch thick. The insert lasted for 1400 hours when $^1/_4$ inch at the bottom of the tube and the crimped extension flange crumbled away. The insert was cut down in length and reinserted in an Alundum base (RA–1099 Norton Company). The extension flange was welded instead of crimped to the lower end of the tube and the die placed back in use. It lasted only 500 additional hours. New dies made up like the remodeled die also gave out quickly. In every case the lower ends of the funnel (the tube) dropped out.

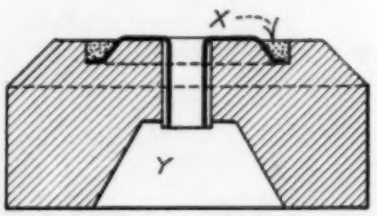
These failures were due to two outstanding difficulties. (1) Glass leaked around the upper end of the flare and then flowed down between the insert and the refractory. As a result of this on the weekly shut-downs the glass put a considerable strain on the platinum and forced it out of shape. (2) However, the prime cause of the rupture was that the glass which came down between the insert and the refractory had forced the collar on the exit end of the insert down beyond the end of the refractory. As a result, the glass ring anchored the platinum liner so that on cooling down the insert was stretched and came apart at the weakest point, *i.e.*, the top of the tube, *F*, where the metal work strain was most severe. The welding of the flange to the tube had not been satisfactory.

This die proved, however, that the platinum-rhodium alloy was the right material for the insert and all further work concerned only details of improvement.

(4) Die No. 4 Three changes were made in this die to overcome the difficulty experienced with die No. 3. (*a*) The method of working the metal was changed, *i.e.*, the tube was drawn to size. The top or apron was rolled sheet shaped to the form desired. (*b*) The apron was welded to the flared upper end of the tube. (*c*) The exit end of the die was reinforced with a collar 0.010 inch thick welded thereto. The whole insert was suspended in the base and floated from the top flange or apron. This arrangement permitted free movement of the insert on heating up and cooling down (see Fig. 6).

The platinum alloy inserts of this type of construction are still in service after 3500 hours of use without any apparent wearing of the metal. The shape of the apron has not proved satisfactory for glass has leaked under the edges in spite of the most thorough cementing of the edges to the refractory. This leakage broke the refractories; the inserts were therefore broken out from the old and placed in new supports.

The bell-shaped mouth of the die has been replaced by a flat top. This change reduces lodgment of floating refractories in the die causing trouble. The use of the flat top allows removal of the material without injury to the die.



Assembly of parts shown above

FIG. 6.

(5) Die No. 5 This die is a variation of No. 4. The edge of the apron instead of being tapered is turned down as shown in Fig. 2. It was originally desired that die No. 4 be made in this shape but the platinum workers hesitated at making the sharp apron.

Since this double apron has been used, the problem of leakage, which was so bothersome with

die No. 4, has been brought down to a minimum. A liner of this shape has already served 1200 hours without leakage.

Acknowledgment In handling the metal working during this investigation, the writer has had the active coöperation of Baker & Company of Newark, New Jersey, manufacturers of platinum ware.

B. FLOW OF GLASS THROUGH TUBULAR ORIFICES

By H. K. Richardson

Note: The data given in this part of the paper were obtained during routine operation. It is not as precise as the writer would wish it to be, but a study of this material has indicated the probable relationships which apply to the flow of glass through tubular orifices. In all the data given the word "die" is used and should be understood to mean a tubular orifice.

I. The Problem

After the first platinum-rhodium die had been found commercially available and the right size determined experimentally for one glass and base, it was desired to extend its use. Since each different liner required a new spinning tool it cost about $100 to make a mistake, so attempts were made to calculate the die sizes by use of known formulas for viscous flow.

II. Calculation by Poiseuille's Formula

The first attempts to use Poiseuille's equation $\left(Q = \frac{KhD^4}{ZL}\right)$ did not give satisfactory results. It was then suggested that a factor be added to the length allowing for the diameter. The equation in this form was $Q = \frac{KhD^4}{Z(L + AD)}$. A was determined from the flow through the first die at several different temperatures. It proved to be a variable with temperature. This was a meaningless physical symbol as far as could be determined.

III. First Experimental Data

The original die was lengthened and shortened and the flow compared with a slightly smaller sized die. The determination of the flow from these combinations over a short interval of temperature, 1250 to 1300°C, brought out the following indications: (*a*) flow was proportional to $D^{2.5}$ and (*b*) flow was inversely proportional to $L^{0.5}$.

The information suggested the possibility that Fanning's equation for flow of viscous oils through pipes was applicable to this problem.

IV. Checking by Fanning's Equation

For the purpose of the writer, Fanning's equation $\left(p = \frac{0.0538 f L S Q^2}{D^5}\right)$ is transferred over to the following form $M = \frac{1.315 \times D^{2.5} \times h^{0.5}}{f L^{0.5}}$ and for $\frac{DVS}{Z}$ is substituted $\frac{M}{DZ}$. The symbols used are defined on p. 244.

Several dies were made up using assumed values of f and viscosity. One of these dies flowed the proper quantity at a temperature within 5°C of the calculated point but the others, especially those of the harder glasses, were over 30% off.

V. Data from Operation

The dies that could be used were put into operation. The flow from these and others was recorded regularly during operation. A few test runs over a range of 150°C were made.

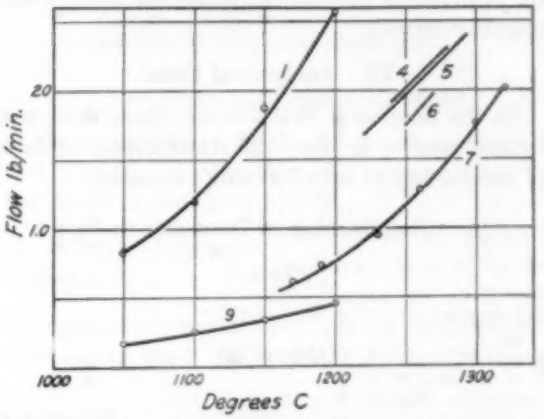


Fig. 7.—Flow of glass *vs.* temperature. Bell-top platinum dies; various glasses; various sized dies; temperature measured with Pyro-optical pyrometer.

Curve No.	Glass No.	Die: Diameter	Die: Total length	Type of curve	Depth of glass (approx. in.)
1	C	0.756	2.25	Test	3.5
4	B	0.719	2.25	Av.	"
5	B	0.756	3.00	"	"
6	B	0.719	3.00	"	"
7	A	0.756	2.25	Test	"
8	B	0.690	2.25	"	"
9	C	0.375	2.25	"	"

The best of these flow data is brought together in two curves, Figs. 7 and 8.

Figure 7 represents dies with the bell top and temperatures determined with the Pyro-optical pyrometer.

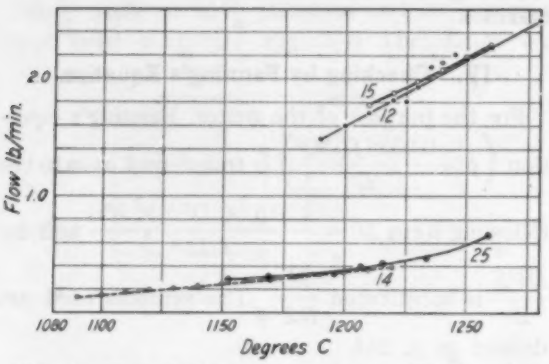


FIG. 8.—Flow of glass *vs.* temperature. Flat-top platinum dies; various sized dies; temperature measured with Bacharach optical pyrometer.

Curve No.	Glass No.	Die Diameter	Die Length	Die Depth	Pressure head in inches of glass: Furnace pressure	Pressure head in inches of glass: Total	Kind of curve
12	B	0.720	1.75	3.5	1.1	4.6	Av.
14	C	0.375	1.75	2.9	0.8	3.7	"
15	B	0.720	1.50	3.5	1.1	4.6	"
25	A	0.562	1.50	3.5	1.2	4.7	Test

Figure 8 represents the flat top dies and temperatures determined with a Bacharach optical pyrometer coupled to a Leeds & Northrup potentiometer for the measurement of comparison filament current.

VI. Analysis of Data

In the discussion that follows, these data will be analyzed to see how the relationships of each of the factors fit into Fanning's equation.

(A) Relationship of Diameter to Flow

TABLE I

Glass C					
Die length (in.)			2.25	2.25	
Diameter of die (in.)			0.375	0.756	
Curve No. (Fig. 7)			9	1	
Temperature (°C)	Flow (lb./min.)		Ratio of Flow	Ratio of Diameter	Relationship of flow (lb./min. to diameter ^{x})
			$\frac{0.756 \text{ in.}}{0.375 \text{ in.}}$	$\frac{0.756 \text{ in.}}{0.375 \text{ in.}}$	
1050	0.165	0.84	5.09	2.016	2.33
1100	0.250	1.22	4.88	2.016	2.26
1150	0.345	1.80	5.22	2.016	2.36
1200	0.445	2.57	5.77	2.016	2.50
	(*A*)	(*B*)	(*C*) $\frac{B}{A}$	(*E*)	2.36 av.

$^{x}x = \frac{\log C}{\log E}$

The preceding table is a compilation of the most trustworthy data and represents the situation fairly accurately.

These data are corroborated by two other isolated cases at single points as follows:

Glass B

(1) At 1240°C ratio of flow $\frac{0.719 \text{ in.}}{0.690 \text{ in.}}$ die was to diameter as $D^{2.45}$

(2) At 1250°C ratio of flow $\frac{0.756 \text{ in.}}{0.719 \text{ in.}}$ die was to diameter as $D^{2.80}$

x, calculated from a large amount of less reliable data, ranges from 1.3 to 3.4 with an average of 2.3

In conclusion it therefore appears justified that flow in pounds per minute varies as (diameter)$^{2.5}$.

(B) Relationship of Flow to Length of Die

The best figures for this relationship are given in the following table.

TABLE II

Glass B					
Die length (in.)			3.00	2.25	
Diameter of die (in.)			0.719	0.719	
Curve No. (Fig. 7)			6	4	
Temperature °(C)	Flow (lb./min.)		Ratio of Flow	Ratio of Die length (in.)	Relationship of flow (lb./min. to $\frac{1}{L^x}$)
			$\frac{B}{A}$	$\frac{3.00}{2.25}$	
1250	1.73	2.01	1.162	1.333	0.52
1260	1.85	2.11	1.140	1.333	0.46
1270	1.97	2.22	1.128	1.333	0.42
	(*A*)	(*B*)	(*C*)	(*D*)	0.47

$x = \frac{\log C}{\log D}$

For Glass *C*, a few isolated cases give an average power of 0.43.

It is thus probable that the effect of length is flow in pounds per minute varies as $\frac{1}{L^{0.5}}$.

(C) Relationship of Viscosity versus Flow

According to Poiseuille's equation, the flow is inversely proportional to the viscosity. In Fanning's equation, the viscosity is one factor in f, the friction constant in which the viscosity appears inversely.

To evaluate this factor, the viscosity of the three glasses was determined by H. R. Lillie of the Corning Glass Works Laboratory. These data are plotted on Fig. 9. The calculated analyses of the glasses are given in Table IV.

Curves 7 and 1 from Fig. 7 are replotted on Fig. 10 as flow per minute versus viscosity. These

curves were made with the same bell-top die, 0.756 inch in diameter, 2.25 inches long.

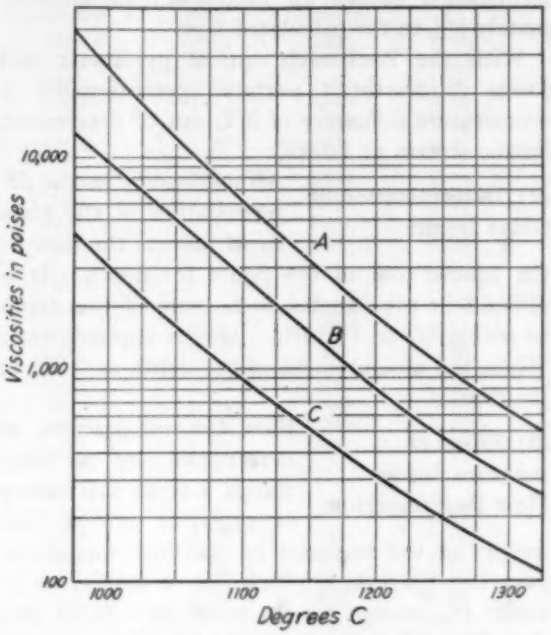


FIG. 9.—Absolute viscosity *vs.* temperature. Westinghouse base glasses determined at Corning Glass Works by H. R. Lillie, December 12, 1932.

It is interesting to note how the curves for two very different glasses join so nicely and make approximately one curve.

The relationship of flow to viscosity tabulated below was taken from these curves and from curves 5, 8, and 9 (Fig. 7), and curves 12 and 14 (Fig. 8).

TABLE III

Glass	Curve No.	Temperature range (°C)	Relationship of flow to $\frac{1}{Z^x}$	Die: Diam. (in.)	Die: Length (in.)
C	1	1050–1200	1.48	0.756	2.25
C	1	1150–1200	1.63	"	"
A	7	1150–1200	1.63	"	"
A	7	1180–1300	1.32	"	"
B	5	1240–1300	1.73	0.756	3.00
B	8	1150–1250	1.53	0.690	1.25
B	12	1190–1280	1.74	0.720	1.75
C	9	1050–1200	2.15	0.375	2.25
C	14	1090–1220	1.18	0.375	1.75
			1.60 av.		

$$x = \frac{\text{log ratio flow}}{\text{log ratio viscosity}}$$

This tabulation seems to indicate that flow in pounds per minute varies as $\frac{1}{\text{viscosity}^{1.6}}$.

Later in the discussion of the entire data the use of the viscosity in the factor, f, of Fanning's equation looks like a better expression of effect of viscosity on the flow.

TABLE IV

ANALYSIS OF GLASSES USED

The calculated analyses of the glasses used are as follows:

	(C)	(B)	(A)
SiO_2	66.0	71.2	75.5
Na_2O	21.6	16.1	13.6
CaO	2.5	4.8	4.1
MgO	1.7	3.9	2.6
MnO_2	6.9	1.7	1.5
R_2O_3	0.9	1.3	1.1
PbO	0.4	1.5	1.3
Cr_2O_3		0.2	0.3

These glasses are all made up from bulb cullet (lime-magnesia-glass) with the coloring material added. The calculated analyses are very close to the actual analysis.

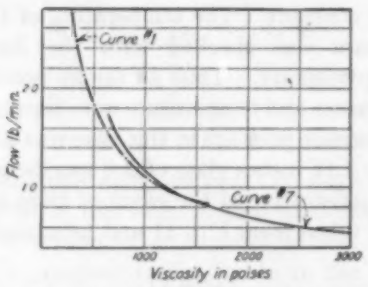


FIG. 10.—Curve No. 1, glass C; curve No. 7, glass A. Same furnace conditions and bell-top die; 0.756 in. diameter; 2.25 in. long; stream temperature by Pyro-optical pyrometer.

(D) Effect of Hydrostatic Head

The hydrostatic head in a furnace is made up of two parts: (*a*) the furnace pressure and (*b*) the depth of glass over the die.

(1) Effect of Furnace Pressure

The effect of furnace pressure is seen when the oil burner is shut off. Measurements made when the oil is turned off at charging show the following figures.

TABLE V

Die	Glass	Glass level over die	Temperature (°C)	Flow (lb./min.): Oil on	Flow (lb./min.): Oil off	Change (%)
690–1½	B	4.13	1245	1.50	1.31	12.5
720–1½	B	4.13	1241	2.00	1.75	12.5
562–1½	A	3.50	1242	0.344	0.281	18.4
375–1½	C	3.50	1180	0.250	0.234	6.25

It is thus seen that taking the pressure off the top of the glass has resulted in the reduction of the flow by 6 to 18% according to the glass in use

The best data indicate that the normal pressure in a furnace running glass B is approximately 2.5 inches of water.

Theoretically the effect of pressure is the same whether it comes from the weight of the glass or the furnace pressure, but the data seem to indicate that the latter is somewhat more effective than the former. Since the determination of the furnace pressure is difficult, due to swirls, it is assumed to be equivalent to the corresponding weight of glass. Thus 1 inch depth of glass of 2.4 specific gravity is equivalent to 2.4 inches H_2O furnace pressure.

(2) Effect of Change in Depth of Glass The effect of change in glass height is shown in Fig. 11. These data were taken when the burner air opening was set to a positive setting in order to keep the furnace pressure constant. The temperature of the flowing stream was checked with the Bacharach optical pyrometer. Thus as far as possible furnace pressure and temperature were kept constant.

The furnace pressure in this case was 2.8 inches water or 1.17 inches glass of 2.4 specific gravity.

Data illustrative of the effect of glass depth on flow are taken from Fig. 11 and tabulated below.

TABLE VI

	Glass depth	Equivalent furnace pressure in inches glass	Total pressure h in inches glass	Flow (lb./min.)
(1)	5.0	1.17	6.17	2.34
(2)	4.0	1.17	5.17	2.11
(3)	3.0	1.17	4.17	1.91

Depth	Ratio of Flows	Ratio of Depths	Relationship of flow/lb./min. to h^x
1 to 2	1.108	1.194	0.58
2 to 3	1.104	1.235	0.47
1 to 3	1.222	1.480	0.51
			0.52 av.

$$x = \frac{\text{log ratio flows}}{\text{log ratio depths}}$$

It thus appears as if flow in pounds per minute varies as depth$^{0.5}$.

(E) Discussion of Effect of Inaccuracies

(1) Temperature Measurement of temperature plays an important part in the accuracy of the determination of any of these relationships, especially that of viscosity. A change of 20° (±10°) in the determination of the temperature would affect the power (D^x) of the flow *versus* diameter by 10%.

Since the viscosity of the glasses at the flow temperature doubles every 60° and the viscosity affects the flow approximately inversely as the 1.5 power, an error of 10° in the temperature determination causes an inaccuracy of approximately 8% in the calculated flow.

With the Bacharach optical pyrometer and Leeds & Northrup portable potentiometer a temperature difference of 3°C can be determined on the stream at 1200°C.

(2) Determination of Glass Depth An inaccuracy in the determination of the glass depth affects the flow as the square root of the figure for depth. It is difficult in the furnace to be sure of the depth to within $^1/_8$ to $^1/_4$ inch. This is approximately 5% in the measurement of the depth or 2.5% in the flow.

(3) Effect of Inaccuracies in Flow Determination Flow for one minute, as determined by a stopwatch, has an inaccuracy of probably 0.5%. The weight of the material in the flow was determined on an ordinary balance; it is in error by about 1%, except for the small dies (0.375 inch diameter) where the error may be 5%.

(4) Effect of Inaccuracies in Determining Furnace Pressure The determination of the furnace pressure is an extremely difficult matter and is probably not accurate to within 10%. In addition it is difficult to adjust an oil burner so that while the temperature of the glass may remain the same the pressure in the furnace will be the same. This effect has probably affected the accuracy of all the flow data, for in the early tests its full significance was not appreciated.

(5) Effect of Temperature Expansion of the Platinum Die Using the figure of mean expansion of platinum from 0 to 1200°C as 9.9×10^{-6}, the total change in the diameter of the die over this range of temperature is approximately 1.25%. Over any range of 200°C, 1000 to 1200°C, the change is only 0.2%. This effect on flow is probably not over 0.5%.

(6) Effect of Change in Glass Composition during a Run Since the curves represent runs over various lengths of time and the furnace was charged intermittently every 20 minutes, softening-point determinations by the Littleton method were run on all the glasses at regular intervals.

These vary as follows: glass A from 717 to

TABLE VII

CALCULATION OF f FROM FANNING'S EQUATION

Glass A Temperature (°C)	M (flow)	Z (viscosity)	f	M/DZ	Total pressure glass (in.)	Die Diameter (in.)	Die Length (in.)	Curve No.
1160	0.64	2800	1.46	0.000302	4.6	0.756	2.25	7
1190	0.70	1950	1.33	0.000475	"	"	"	"
1220	0.90	1400	1.04	0.000850	"	"	"	"
1250	1.15	1020	0.81	0.001492	"	"	"	"
1280	1.47	760	0.64	0.002554	"	"	"	"
1310	1.87	590	0.50	0.004190	"	"	"	"
1160	0.29	2800	1.93	0.000184	"	0.562	1.50	25
1190	0.34	1950	1.64	0.000310	"	"	"	"
1220	0.42	1400	1.33	0.000534	"	"	"	"
1250	0.58	1020	0.96	0.001029	"	"	"	"
Glass B								
1190	1.48	930	0.68	0.002210	5.2	0.720	1.75	12
1220	1.82	670	0.55	0.003770	"	"	"	"
1250	2.16	495	0.46	0.006060	"	"	"	"
1280	2.50	370	0.40	0.009380	"	"	"	"
1230	2.34	600	0.508	0.005400	6.33	0.720	1.50	Fig. 9
1230	2.11	600	0.517	0.004880	5.33	"	"	" 11
1230	1.91	600	0.514	0.004420	4.33	"	"	" 11
Glass C								
1100	0.13	900	1.37	0.000385	4.3	0.375	1.75	14
1130	0.21	640	0.85	0.000875	"	"	"	"
1160	0.27	465	0.66	0.001550	"	"	"	"
1190	0.32	340	0.55	0.002510	"	"	"	"
1220	0.39	255	0.46	0.004080	"	"	"	"

721°C, glass B from 687 to 693°C, and glass C from 644 to 650°C.

This indicated a satisfactory uniformity of the glass, but even at that a 6°C reduction in the softness means a 6% increase in the viscosity which is a 9.8% reduction in the flow.

(7) Shape of Stream The glass stream necks down quickly from the die exit becoming perfectly cylindrical all the way down from 6 inches below the die. In the case of a 0.756-inch diameter die this cylinder is about $^1/_8$ inch in diameter.

Evidently about 6 inches below the die exit the forces acting become balanced so that a constant volume is flowing past a point at any given time. The temperature of the first 18 inches below the 6-inch point is the same as far as can be measured.

(F) Application of Fanning's Equation to Flow Data

All of the factors in Fanning's equation have been evaluated in separately checked test runs or from average data taken from routine operations in the tables which have gone before, and in every case the factors have indicated the same power as would be found in Fanning's equation itself, except for viscosity. If, therefore, the f of the Fanning's equation could be shown to fall upon a straight line when plotted according to the method of Wilson,[1] then it could be held that the Fanning's equation is applicable to the flow of glass.

In Table VII the factor, f, is calculated for each of the three different glasses using three different lengths and four different diameters of dies. In addition, f has been calculated from the data given with Fig. 11.

The data of the table are plotted on Fig. 12. It will be noted that all of the points except for

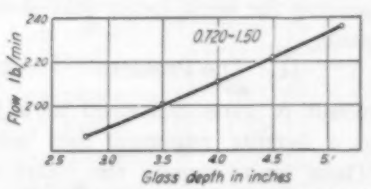


FIG. 11.—Flow of glass *vs.* depth of glass. Glass B, die, 0.720 in. diameter; 1.50 in. long; furnace pressure adjusted to a constant for each measurement-temperature of stream 1230°C.

the small die, glass C, fall on a straight line within the experimental error while the data for the small die, glass C, are nearly parallel to and not

[1] Wilson, *et al.*, *Jour. Ind. Eng. Chem.*, **14**, 114 (1922).

far from the straight line combining the other data.

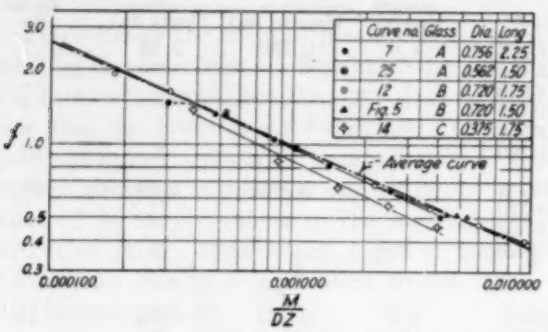


FIG. 12.— f of Fanning's equation *vs.* $\frac{M}{Dz}$. NOTE: Fig. 5 (above) should read Fig. 11.

VII. Conclusions

The writer therefore concludes that Fanning's equation,

$$M = \frac{1.315 \times D^{2.5} \times h^{0.5}}{f \times L^{0.5}}$$

where f is a function of $\frac{M}{DZ}$, fairly represents the flow of glass from tubular orifices. Strange as it may seem the results indicate that this flow is turbulent, not viscous.

SYMBOLS USED IN FORMULAS

D	= diameter (in.)
L	= length (in.)
h	= glass depth (in.), which includes (1) actual glass depth, and (2) equivalent furnace pressure
M	= glass flow (lb./min.)
S	= specific gravity (assumed to be 2.4 at 1200°C)
Z	= viscosity (poises)
Q	= quantity (volume/unit of time)
V	= average linear velocity (ft./sec.)
A and K	= constants
f	= friction factor (Fanning's equation)

The symbols in the Poiseuille's equation are general and not those given above.

C. THE AUTOMATIC CONTROL OF TEMPERATURE OF SMALL GLASS STREAMS BY MEANS OF RADIATION PYROMETERS

BY H. K. RICHARDSON* AND F. A. NEWCOMBE†

I. Introduction

The glass delivered to the glass base machines is fed from a small tank of inside dimensions 27 by 78.5 by 15 inches, fired from one side by one oil burner which is both melting burner and delivery burner. The batch is charged intermittently every twenty minutes; during this period the oil burner is shut off about one minute. Due to the small size, no stack is used, so a positive pressure exists in the furnace. It is run continuously during the week, being shut down over the week-ends.

II. The Problem

The amount of glass contained in a base is limited to a definite minimum and maximum height. These limits require the following discharge of glass.

AMOUNT OF GLASS DELIVERED

Type of lamp base	Per base/grams			Per minute/lb.			Size of stream diameter (approx. in.)
	Min.	Max.	Av.	Min.	Max.	Av.	
Common house	4.07	4.90	4.35	2.05	2.47	2.20	1/8
Miniature	0.210	0.226	0.218	0.31	0.33	0.32	1/32

* Engineering Dept., Westinghouse Lamp Co., Bloomfield, N. J.
† Engineer, Westinghouse Lamp Co., Belleville, N. J.

When these figures are translated through the viscosity curves into temperatures, the allowable changes in temperature of the glass stream appear to be (*a*) house lamp: 1232 to 1278°C, average 1245°C and (*b*) miniature lamp: 1180 to 1190°, average 1185°C.

Due to the need of allowing for the effects of lumps or seeds in the stream, the full range of temperature can not be taken. Since the allowable shrinkage in the product is only 1% in case of the medium screw house lamp base and 2% in the case of the miniature base, a lump or seed will cause loss unless the process is controlled within much narrower limits than given above. In the case of the smaller base, since it is impracticable to flow glass through any smaller die than one 3/8 inch in diameter, much of the flow must be blown off and therefore partial regulation is obtained in this manner.

Pulsating effects in the oil burner and control apparatus also must be allowed for, so it has been found that the best operating conditions are obtained when, for (*a*) medium screw (house lamp) bases, the glass temperature is held closer than ±10°C, and for (*b*) miniature bases, the glass temperature is held closer than ±5°C.

III. Requirements of a Successful Control

The requirements that a temperature control must meet to be successful on this work are as follows: (*a*) must control temperature to ±5°C on $^1/_{32}$-inch stream at 1200°C; (*b*) must be capable of handling excess pressure effects when the oil burner is opened up after charging, *i.e.*, must not pulsate; (*c*) should operate from the glass stream itself; (*d*) must be reliable when subjected to heat and abuse; (*e*) must remain set for a week's run; and (*f*) should be of standard equipment if possible, making replacements easy.

IV. Solution of the Problem

An assembly of instruments has been made which practically meets the requirements above given. This combination has been the result of several years development, the salient features of which are noted later in the History of Development, in (C) p. 247.

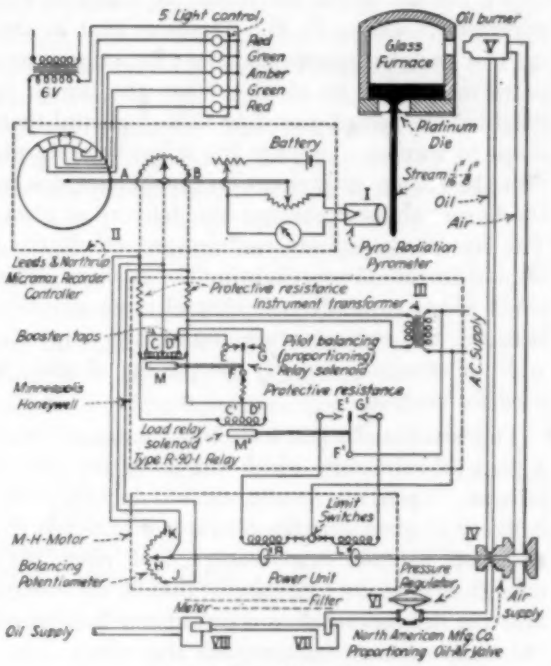


FIG. 13.

The component parts of the standardized layout are to be noted in Fig. 13.

(A) The Instruments

I. A Pyro-supersensitive radiation pyrometer in a water jacket. Its response is 60 millivolts when sighted on a 1-inch diameter surface at 1300°C. When sighted on the $^1/_8$-inch stream, the response is 3 to 4 millivolts, while the response for the $^1/_{32}$-inch stream is about 1 to 1.5 millivolts. Changing the arrangement of the optical system raises the response to 2 to 3 millivolts on the $^1/_{32}$-inch stream. At the point of use, about 1200°C, 0.1 millivolt corresponds to 5 to 5.6°C.

II. A Leeds & Northrup micromax potentiometer recorder controller with a 0- to 6-millivolt range on the 10-inch chart. Disks on the shaft carry (1) the resistance A.P.B. for the M-H motor (see III), and (2) the contacts R1, R2, G1, G2–A_0 for the five-light indicating control for the operator's use.

III. A Minneapolis Honeywell proportionating motor control which operates IV (see Fig. 1, p. 236).

IV. A North American Equipment Company proportionating oil-air valve which controls the flow of oil and air to V.

V. A North American Equipment Company style "DA" 3-inch oil burner modified to suit the operating conditions of the furnace.

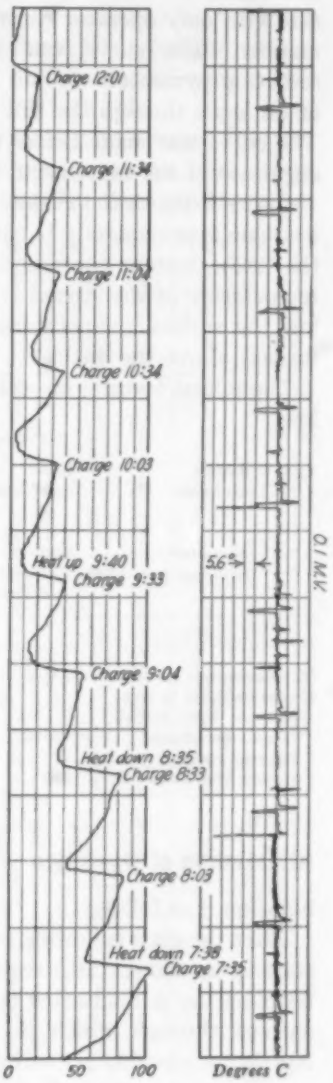


FIG. 14.

VI. A pressure control for the oil line.

VII. A National integrating oil meter.

VIII. A Cuno filter on the oil line to assure uninterrupted running.

(B) Results Obtained

Figure 14 shows side-by-side curves, illustrating the results obtained with the new outfit com-

pared with a record when no control was in use. The difference is an overall picture of the magnitude of the change in operating conditions resulting from the installation of the standardized control.

Curve *A* shows the variation in the temperature of the glass surface over the die during an ordinary run with only operator control in the traditional manner. The curve was taken by a Foster radiation pyrometer sighted on the glass surface at an angle through the side wall of the furnace. The curve was made before the operator became cognizant of the experiment.

Curve *B* shows the variation in temperature of a stream approximately $^1/_{16}$ inch in diameter when the latest system controls the oil burner. The temperature of the stream is less than 100°C below the surface temperature of the glass in the furnace above the die.

The salient features of each curve are noted below.

	Curve *A*	Curve *B*
Type of control	None	Full automatic
" " die in use	Old porcelain with plug	New platinum-rhodium -alloy liner
" " oil burner	Local	North American
" " radiation pyrometer	Foster-on surface of glass	Pyro- with modified optical system—directly on stream
Oil consumption gal./hr.	7 to 8	6
Maximum range in temperature, 5-hr. period including charge	103°C	28°C
Between charges, 20 min.	110°, av. 48°C	6°C, av. 2°C
During week's run	200°C	7°C

(C) Method of Operation

Present practice in operating this combination is as follows:

After the glass is flowing properly at the weekly starting-up time, the stream temperature is determined by a Bacharach optical pyrometer, the current through which is read on a Leeds & Northrup portable potentiometer provided with a current coil. A very accurate and reproducible reading of the temperature is obtained. The temperature of the stream is brought to standard by manual operation of the oil valves. The radiation pyrometer is then focused on the stream until the center indicator light is burning and then accurately brought to the center setting on the micro-max, after which it is securely locked in position. The indicator on the oil valve and the proportionating motor are brought to the proper setting. Rarely is further adjustment needed in a week's run.

The only precaution to be observed to keep accurate control over a week's run is to wipe off the quartz lens occasionally at the front of the pyrometer. This is the first duty of the operator when each shift reports for work. The effect of this is seen from *X*, curve *F*, Fig. 15, where the cleaning is seen to have raised the temperature about 1°C.

V. Discussion of Peculiarities

(A) What Is Being Measured

We have spoken of measuring the temperature of the stream. The image of the stream covers only a portion of the thermocouple target in the pyrometer. Curve *F*, Fig. 15 shows that at the start of the charging period the temperature appears to drop 12 to 15°C. When the burner is relighted the record goes 6 to 12°C high and then drops to normal. On page 241 it has been shown that the change in pressure in the furnace due to the burner shut-off changes the delivery of glass. The size of the stream is decreased on shutting off and increased on relighting the burner. This effect seems to render the control more sensitive because the temperature multiplied by the width of stream or roughly the volume of glass is used for control.

This was noted when a die became clogged with a piece of refractory which cut down the size of stream. There was no noticeable reduction in the delivery of glass, but the operator discovered the situation for the temperature had risen high enough to melt the brass shells; that is, the control held the delivery of glass constant and had raised the temperature to accomplish this effect.

(B) The Optical System of the Pyro-Radiation Pyrometer

The optical system as originally received presupposed that the object on which the pyrometer would be focused would be at a distance. This system could be used as is for the $^1/_8$-inch stream. When used on a $^1/_{32}$-inch stream the millivolt response was too small, so the optical system was changed by lengthening the tube holding the lens. In this way the image on the target was enlarged and sharpened.

(C) History of Development

The earliest efforts at control were merely attempts to record what was happening in the furnace.

(1) Thermocouples Rare metal thermocouples in the atmosphere of the furnace or inserted from the side of the furnace under the glass level in porcelain protection tubes proved to be too expensive to be practicable.

(D) Radiation Pyrometers

(1) The Foster Tube A Foster radiation tube sighted through the side wall of the furnace gave an excellent record of the temperature changes (see curve *A*, Fig. 15). Therefore, it was connected to a Leeds & Northrup recording controller which controlled the oil and air valves by means of an Automatic Temperature Control Company 2-point controller. This looked like a solution of the problem, for this control held the temperature to within plus or minus 20°F over long periods and much finer control for short periods (see curve *B*, Fig. 15).

The upkeep of the gold-plated mirror and the difficulty of placing the instrument and its water jacket in the furnace wall did not appeal to the operating force and prevented the general adoption of the unit.

(2) Five-Light Indicating Control Pyro-Radiation Tube To help the operator to control for short periods with the old die, a system of five-light indicating control was established. It was first necessary to find a satisfactory means of stream temperature measurement. It was decided that all pyrometers and parts of instruments must be kept outside the furnace walls. The Pyro-sensitive radiation tube used in the latest standard outfit was found to be satisfactory for the purpose when used arbitrarily. Connected to a Leeds and Northrup recording micromax, the same as used in Fig. 13, carrying on its shaft contacts connected to lights at the operator's side, it became an established unit. Amber was the working light with a green just above and below, while above and below each green was a red light. Each contact represented approximately 5°C change in temperature. The contacts for the lights were adjusted to the operator's conditions as the changing die size required. He then could run for a period under some control. Figure 15, *C*, indicates how successful this method was. The operator usually stayed within ± 15°C of the assigned temperature but tended to run on the high side.

While using this control it was found that the advertised lag of the pyrometer, *i.e.*, 2 seconds, was exceeded in practice, for when a furnace was

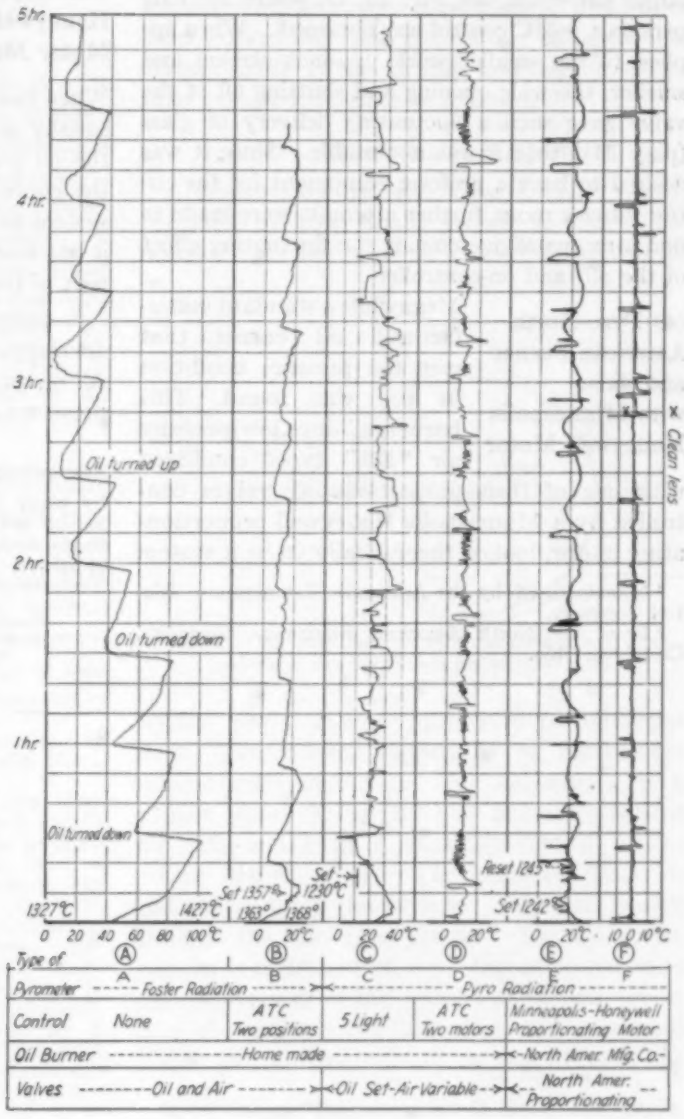


FIG. 15.

shut down a change in millivoltage occurred $1^3/_5$ seconds later and was completely stabilized in 6 seconds.

(3) Pyro- and Automatic-Temperature Control Balancing Motor The Pyro-radiation pyrometer with its micromax recorder was connected to a balancing motor control.[2] The one motor control was discarded for it did not work as well on the sensitive stream as it did when sighted on the surface of the glass. The motor controlled the air valve only, the oil being fed through a carburetor which kept it proportionate to the air. This control proved excellent for the larger size work, see Fig. 15, *D*, where for long periods a ±5°C control was obtained. When applied to the smaller work, $^1/_{16}$-inch stream and smaller, the wide opening and shutting off of the valve gave such a fluctuating delivery of glass (page 241) that it was not usable. Since it was desired to have a uniform equipment for the entire furnace room, further attempts were made to find a means of overcoming the fluctuating effect of the off- and on-controller.

(4) Pyro-North American Burner and Valve with Minneapolis Honeywell Motor Meanwhile a standard manufactured oil burner that met the pressure condition in use was found. This burner, a 3-inch low-pressure air "DA" type[3] combined with one of their proportionating valves controlled by a Minneapolis Honeywell proportionating motor, looked theoretically to be a system which would oviate the fluctuating effect that had caused trouble in the small size stream.

The results were not at first so good a control as that obtained from the other combination in paragraph (3). The fluctuating effects were, however, not present. Since the control was to ±5°C, except for the charging period, it was felt that an improvement had been made (see Fig. 15, *E*, for a representative curve obtained with this combination).

(5) Pyro-North American Burner Valve and Minneapolis Honeywell Motor Modified Experience gained from using control No. 4 led to the discovery that the burner hookup could be changed to advantage. Originally the auxiliary air was piped in independent of the control. When this 10% of the full air or some 50% of that usually in use was placed under the control valve, the oil consumption of the burner dropped and the curve *F* (Fig. 15) was obtained. Since this system as modified is useful on all types of bases it has now been standardized as noted in the first part of the paper.

A comparison of the results obtained from this development is seen in the curves on Fig. 15. All of these curves are plotted to the same temperatures and time coördinates.

Acknowledgments The sincere coöperation and efforts to solve this problem put forward by many manufacturers and their engineering staffs is hereby acknowledged. Particular credit must be given to the work of Mr. Bradley and Mr. Rumford of Leeds & Northrup Company and of the staff of the Automatic Temperature Control Company.

ENGINEERING DEPARTMENT
WESTINGHOUSE LAMP COMPANY
BLOOMFIELD, N. J.

[2] Manufactured by the Automatic Temperature Control Company.

[3] From the North American Equipment Company, Cleveland, Ohio.

X-RAY DETERMINATION OF THE STRUCTURE OF GLASS*

By B. E. Warren

ABSTRACT

A method has been developed for analyzing the X-ray diffraction patterns of amorphous solids, and the atomic arrangement in two simple glasses has been completely worked out. In SiO_2, for example, each silicon is tetrahedrally surrounded by 4 oxygens at a distance 1.60 Å, and each oxygen is shared between two such tetrahedral groups. The mutual orientation of the two groups about their common direction of bonding is random, and hence it is a random three-dimensional network which is built up. The configuration does not repeat at regular intervals and hence is noncrystalline; it is this feature which distinguishes the glassy state from the crystalline.

I. Introduction

X-ray diffraction patterns of glass are readily obtained by passing a fine X-ray beam through a thin slab of glass and registering the diffraction pattern upon a photographic film placed several centimeters behind the sample. X-ray studies of glass have been reported by a number of workers.[1] In most cases one or more broad diffuse rings were obtained, similar to the rings generally obtained with liquids. Except for two of the recent papers (see footnotes 1*e* and 1*g*) however, there has been very little done in the way of a serious attempt to interpret the X-ray diffraction patterns of glass.

It is the purpose of this paper to summarize the results so far obtained in the intensive program of X-ray diffraction study of glass, which has been started at the Massachusetts Institute of Technology. The most promising method of attack appeared to be in making a careful study of the diffraction patterns of one or two of the simplest glasses to obtain a completely satisfactory quantitative interpretation of the diffraction patterns. Once the method of interpretation of glass diffraction patterns is firmly established by the preliminary work on simple glasses, the program can then be extended to include the more complex compositions of interest to glass technology.

Vitreous silica, SiO_2, is one of the simplest forms of glass, and was therefore selected as a suitable material with which to begin the study. Not only is the chemical composition simple, but from the large number of crystalline silicates[2] which have been worked out, the interatomic distances and arrangements of the silicon and oxygen atoms to be expected are quite well known.

II. Experimental Method

Although glass diffraction patterns are readily obtained by this simple set-up, it was found necessary to use a more refined apparatus to obtain really reliable quantitative diffraction data. The present apparatus is represented schematically in Fig. 1. The radiation from a copper target X-ray tube is monochromatized by reflection from a rock-salt crystal set to reflect the K α-line. The reflected beam is collimated by a brass tube and then passed through the thin glass sample. The diffraction pattern is registered on a photographic film held against the wall of the cylindrical camera, which is of the radius 4.40 centimeters, and evacuated during the run to eliminate the scattering of the

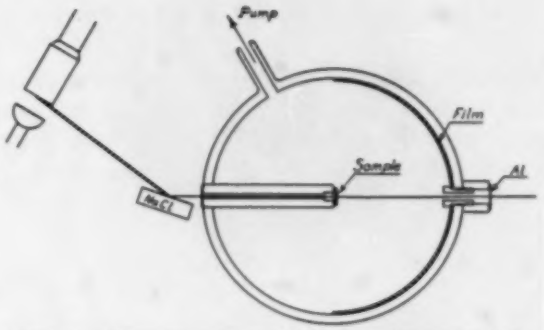


Fig. 1.—Vacuum camera with monochromator for making X-ray diffraction patterns of glass.

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February 14, 1934 (Glass Division). Received March 8, 1934.

[1] (*a*) P. Debye and P. Scherrer, *Nachr. kgl. Ges. Wiss. Göttingen*, p. 16 (1916). (*b*) R. W. G. Wyckoff and G. W. Morey, "X-Ray Diffraction Measurements on Some Soda-Lime-Silica Glasses," *Jour. Soc. Glass Tech.*, **9**, 265 (1925). (*c*) N. J. Seljakow, L. V. Strutinski, and A. J. Krasnikow, *Z. Phys.*, **33**, 53 (1925). (*d*) C. W. Parmelee, G. L. Clark, and A. E. Badger, "The Diffraction of X-Rays by Ordinary Glass Subject to Various Treatments," *Jour. Soc. Glass Tech.*, **13**, 285 (1929); G. L. Clark and C. R. Amberg, "X-Ray Investigations of Feldspar Glasses," *ibid.*, p. 290 (1929). (*e*) J. T. Randall, H. P. Rooksby, and B. S. Cooper, "The Structure of Glasses: Evidence of X-Ray," *Z. Krist.*, **75**, 196 (1930); *Jour. Soc. Glass Tech.*, **14**, 219 (1930). (*f*) I. Levin and E. Ott, "X-Ray Study of Opals (Natural), Silica, Glass, and Silica Gel," *Z. Krist*, **85**, 305 (1933). (*g*) B. E. Warren, *Z. Krist.*, **86**, 349 (1933).

[2] W. L. Bragg, "The Structure of Silicates," *Z. Krist.*, **74**, 237 (1930); *Jour. Soc. Glass Tech.*, **14**, 295 (1930).

X-ray beam in the air path between the sample and film. By these two precautions, *viz.*, monochromatizing the beam by crystal reflection so that a completely monochromatic beam is obtained and evacuating the camera to eliminate air scattering, one eliminates completely the troublesome background blackening which is otherwise so difficult to correct for.

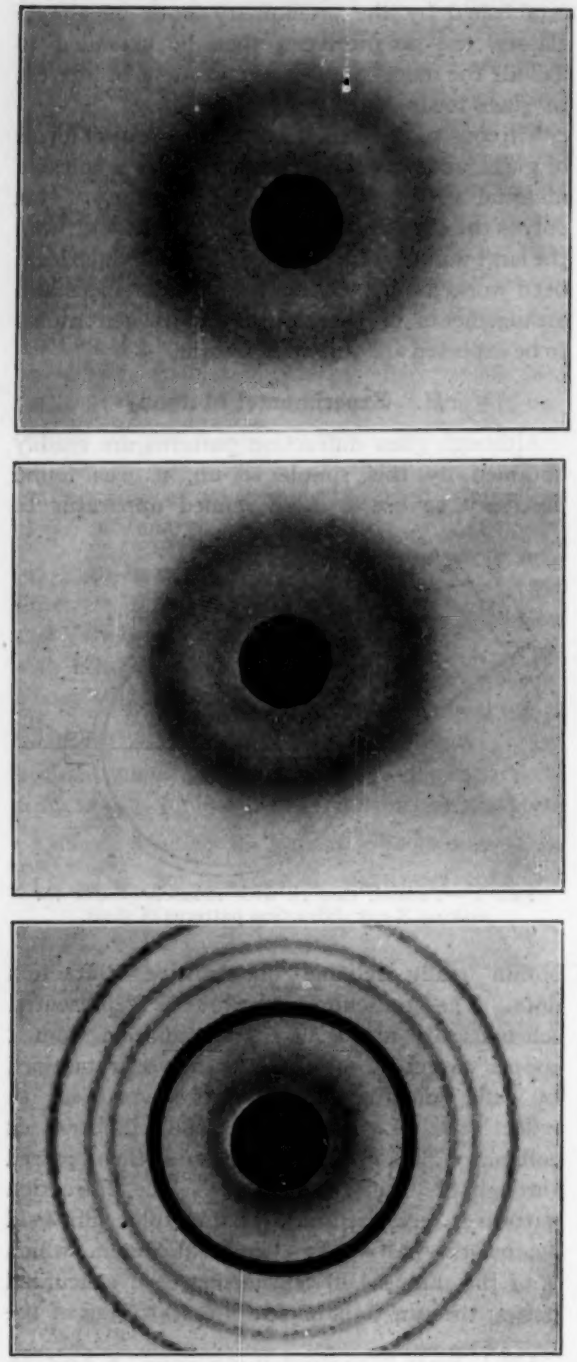


Fig. 2.—X-ray diffraction pattern: (*top*) Pyrex-brand resistance glass; (*center*) vitreous silica; (*bottom*) cristobalite.

For the sample of vitreous SiO_2, a piece of fused quartz tubing was used, and for vitreous GeO_2, 5 grams of powdered oxide were melted in a Vitreosil crucible. In both cases, the thin sample was obtained by blowing a bubble of the material and then picking out a chip of about three-fourths the optimum thickness. With the tube running at 20 milliamperes and 30 kilovolts peak, exposures of 30 hours were found to be sufficient. The microphotometer records of the films were changed to intensity curves by the usual method of making calibration blackening steps on the films.

(1) Methods of Interpretation of SiO_2 Pattern

Figure 2 (*center*) shows the diffraction pattern of vitreous silica. The pattern consists of a strong but diffuse ring whose peak occurs at a scattering angle 2θ which would correspond to a spacing $d = 4.32$ Å in the Bragg law. There is also another much weaker peak at about $d = 1.30$ Å, but this second peak occurs at too large an angle to be included on the reproduction in Fig. 2 (*center*).

Two methods of interpretation of the pattern suggest themselves.

(*a*) Crystallite hypothesis: The pattern is due to the diffraction of X-rays in extremely small crystals.

(*b*) Random network hypothesis: The ring is due to the scattering of X-rays in a noncrystalline network of silicon and oxygen atoms.

(a) Crystallite Hypothesis

If a sample of vitreous silica is held at 1500°C for several hours it devitrifies completely to cristobalite. The diffraction pattern of this material is shown in Fig. 2 (*bottom*). The very strong ring is the (111) reflection of cristobalite, and occurs at roughly the same scattering angle as the peak from vitreous silica. It suggests itself at once that the diffraction pattern of silica can be interpreted as due to extremely tiny crystals of cristobalite, the observed strong diffuse ring being the strong (111) reflection of cristobalite, and the individual crystals being so small that a broad diffuse ring is produced, rather than the sharp one which is characteristic of crystals of appreciable size. This is the conclusion reached by Randall, Rooksby, and Cooper,[1e] who found that the breadth of the diffuse ring was satisfactorily accounted for by postulating cristobalite crystals of about 15 Å size. The idea that vitreous silica should be

made up of extremely tiny crystals of cristobalite is not at all unreasonable, since cristobalite is the stable form of SiO_2 in the temperature range through which the vitreous silica solidified.

There are, however, certain serious objections to the crystallite hypothesis. For one thing, the spacing obtained from the vitreous silica ring is 4.32 Å, while that obtained from large cristobalite crystals (low-temperature form[3]) is 4.05 Å, a discrepancy of 6%.

Another objection to the crystallite hypothesis comes from the fact that cristobalite undergoes a marked volume change between 200°C and 300°C, whereas vitreous silica shows no such change.

What is probably the most serious objection to the crystallite hypothesis has to do with the behavior of the material under heat treatment. If samples of the material are held for various lengths of time at high temperature, it would be expected that the tiny cristobalite crystals would grow and that the broad diffraction peak would gradually narrow. Actually, however, the broad peak of vitreous silica goes over abruptly into the sharp displaced ring of cristobalite. Furthermore, for tiny crystals of the size postulated, the width of the diffraction peak should be extremely sensitive not only to heat treatment, but also to previous history and origin of the material. It was found, however, that samples of vitreous silica of quite different origin and others having undergone heat treatment as drastic as possible without producing devitrification all showed broad diffraction bands of the same width. These objections to the crystallite interpretation of the diffraction pattern of vitreous silica seem to be sufficiently serious to make it worth while to look for another interpretation.

(b) Random Network Hypothesis

The alternative interpretation is that based upon X-ray scattering from a noncrystalline random network. It is reasonable to suppose that even in such a noncrystalline arrangement, the interatomic distances and coördination will be essentially the same as found in the crystalline forms of silica. Each silicon will be tetrahedrally surrounded by four oxygens with an silicon-oxygen distance of about 1.60 Å, and each oxygen will be shared between two silicon atoms. Assuming that each oxygen lies very nearly upon the straight line between the two silicons to which it is bonded, then the distance between nearest silicons will be 3.20 Å. Although this distance between neighboring tetrahedral groups is perfectly definite, the relative orientations of the two tetrahedral groups around the common direction of bonding is completely random. The resulting 3-dimensional network which is built up is a random network; it does not repeat itself at regular intervals, and the material is accordingly noncrystalline.

The only rigid conditions which it is assumed are maintained in the glass network are those having to do with the silicon-oxygen distance, the grouping of four oxygens about each silicon, and two silicons about each oxygen. Except for these conditions the network is completely random, but in spite of its random nature, the distances from any one atom to the nearest, next nearest, and next next nearest neighbors are perfectly definite, and it turns out that it is just these definite interneighbor distances which determine the X-ray diffraction patterns of the glass.

A method has been developed for calculating the diffraction pattern of a noncrystalline solid such as a glass.[1g] The intensity of scattering is given as a function of the angle by the expression

$$I = \sum_m \sum_n f_m f_n \frac{\sin s r_{mn}}{s r_{mn}} \qquad s = \frac{4\pi \sin \theta}{\lambda} \qquad (1)$$

where f_n is the X-ray scattering factor for atom n, and r_{mn} is the distance from atom m to atom n. It appears from equation (1) that the intensity depends only on the distances from each atom to all the other atoms and that, if these distances are known, the intensity can be immediately written down as a function of the angle of scattering.

The next step is to tabulate the number of neighbors and their distances about any one atom. About any one silicon there will be 1 Si at distance 0, 4 oxygens at 1.60 Å, 4 Si at 3.20 Å, 12 oxygens at 4.00 Å, and 12 Si at 5.20 Å. Thus far, the number of neighbors and their distances are perfectly definite, regardless of the orientations of the tetrahedral groups. Next come 36 oxygens at a distance which is not quite definite,

[3] T. F. W. Barth, "The Cristobalite Structure, II. Low Cristobalite," *Amer. Jour. Sci.*, **24**, 97 (1932).

but varies from 5.0 Å to 6.6 Å, depending on the orientation of the groups. Beyond this the distances become quite indefinite, and a continuous distribution of scattering matter can be assumed and the summation can be carried out by direct integration. Beginning with the 12 Si at 5.20 Å, it is a considerable simplification to replace the discreet array of atoms by spherical SiO_2 scattering units,[4] comprising one Si at the center and two oxygens spread uniformly over the surface of a sphere of radius Si–O = 1.60 Å. The complete distribution of neighbors is listed in Table I.

TABLE I

DISTRIBUTION OF SURROUNDING ATOMS

1 silicon surrounded by		2 oxygens each surrounded by	
1 Si at	$r = 0$	1 O at	$r = 0$
4 O	= 1.60 Å	2 Si	= 1.60 Å
4 Si	= 3.20 Å	$6 \times 1/2 = 3$ O	= 2.62 Å
$12 \times 1/2 = 6$ O	= 4.00 Å	6 SiO_2	= 4.00 Å
12 SiO_2	= 5.20 Å		
Continuous distribution beyond R_1 = 6.05 Å		Continuous distribution beyond R_2 = 4.55 Å	

The integration over the continuous distribution is readily carried out, making the obvious assumption that the outer limits are indefinite and hence give rise to no effect.

$$\int_R^\infty 4\pi r^2 \rho f \frac{\sin sr}{sr}\, dr = -\frac{4}{3}\pi R^3 \rho f \Phi(sR) \qquad (2)$$

where ρ is the density in SiO_2 molecules per cubic centimeter and

$$\Phi(x) = \frac{3}{x^3}\left[\frac{\sin x}{x} - \cos x\right]$$

The intensity of scattering for vitreous SiO_2 is now written out as a function of the scattering angle by inserting the numerical values from Table I into equation (1).

$$\frac{I}{N} = f_{si}\left\{f_{si} + 4f_o \frac{\sin 1.60s}{1.60s} + 4f_{si}\frac{\sin 3.20s}{3.20s} + 6f_o \frac{\sin 4.00s}{4.00s}\right.$$
$$\left. + 12f\frac{\sin 5.20s}{5.20s} - 17f\Phi(6.05s)\right\} + 2f_o\left\{f_o + 2f_{si}\frac{\sin 1.60s}{1.60s}\right.$$
$$\left. + 3f_o\frac{\sin 2.62s}{2.62s} + 6f\frac{\sin 4.00s}{4.00s} - 8f\Phi(4.55s)\right\} \qquad (3)$$

Equation (3) is plotted against $\frac{\sin\theta}{\lambda}$ in Fig. 3*a* and compared with the experimental intensity curve derived from the microphotometer record of the film. Since the experimental intensity is in arbitrary units, the scale of ordinates has been arbitrarily chosen so that the maximum height of the experimental and calculated curves shall be the same. The agreement between the calculated and experimental curves is quite satisfactory, both with respect to the position of the peak and the general shape of the curve. If the calculated intensity curve is carried out to larger values of $\frac{\sin\theta}{\lambda}$, the term $8 f_{si} f_o \frac{\sin 1.60s}{1.60s}$ in equation (3) gives rise to another weaker peak at $\frac{\sin\theta}{\lambda} = 0.38$. This is the weak outer peak mentioned above.

The agreement between calculated and experimental intensity curves is so completely satisfactory that the proposed picture of the atomic arrangement in vitreous silica can be taken as completely substantiated. On the crystallite hypothesis it was impossible to understand the constant width of the diffraction peak regardless of origin or treatment of the material. On the random network hypothesis of the vitreous state, however, it follows immediately, for the scattering curve is determined solely by equation (3) which contains no sensitive variable quantity such as particle size.

(2) Check Example, Vitreous GeO_2 An excellent check upon the correctness of the proposed picture of the atomic arrangement in a simple glass such as SiO_2 is obtained from a study of vitreous GeO_2. From the similarity in the crystalline forms of SiO_2 and GeO_2 it would be expected that the atomic arrangement in vitreous GeO_2 would be essentially the same as in SiO_2. This turns out to be the case. The interatomic distance is slightly larger: Ge–O = 1.65 Å, but otherwise the scheme of grouping is the same.

The intensity of scattering for vitreous GeO_2 is given by an expression of the same form as equation (3), with f_{si} replaced by f_{Ge} and the fundamental cation-anion distance 1.65 Å instead of 1.60 Å. When this intensity expression is plotted and compared with the experimental intensity curve for GeO_2, it is found that the main peak agrees very well, but that the second peak in the calculated curve is somewhat too

[4] While this is only a rough approximation, it is nevertheless a sufficiently good one for the small angles of scattering considered. The appropriate scattering factor for such a spherical unit is given by $f = f_{si} + 2f_o \frac{\sin 1.60s}{1.60s}$.

strong and occurs at too large an angle. A careful analysis of the intensity equation shows that the discrepancy is due wholly to the second order maximum of the strong term $12 f_{Ge} f \frac{\sin (5.35s)}{5.35s}$ and that a satisfactory agreement between the calculated and experimental curves can be obtained only if the distance from Ge to the twelve next nearest Ge neighbors is not the perfectly definite value 5.35 Å which has been assumed, but varies slightly. Since there is no reason why the two bonds to any oxygen should be exactly diametrically opposite, it is quite reasonable to expect that this distance should vary a little. If the distance is assumed to be 5.35 ± 0.60 Å, a fairly satisfactory agreement is obtained between calculated and experimental intensity curves as seen in Fig. 3*b*.

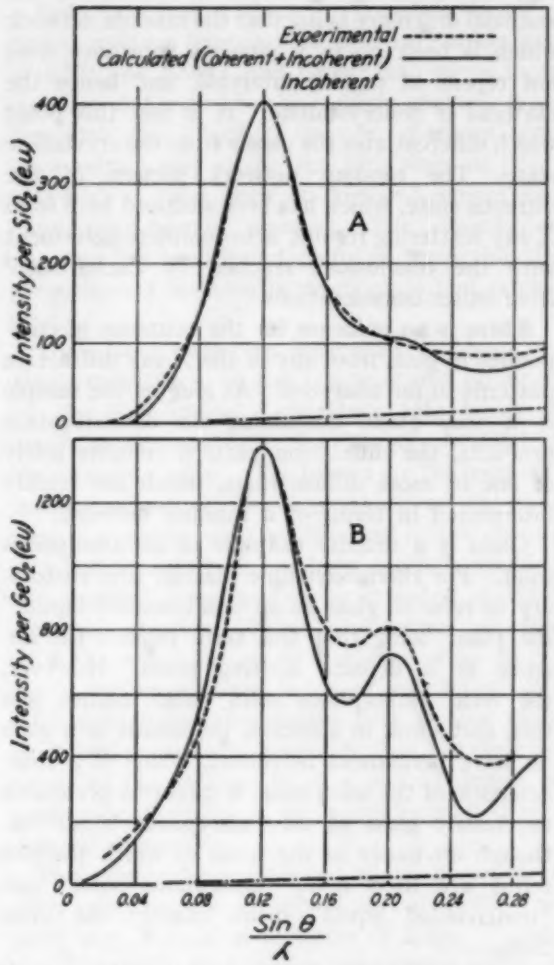


FIG. 3.—Comparison of calculated and experimental scattering curves: (*a*) vitreous SiO_2, (*b*) vitreous GeO_2.

It appears possible that from a more careful and detailed comparison of the calculated and experimental curves, it would be possible to determine not only the kind of atomic grouping and interatomic distances in glass, but also the degree of regularity in the grouping. While a similar variation in the distance to neighboring atoms, due to the two bonds to any oxygen not being exactly diametrically opposite, must also be present in vitreous SiO_2, the effect does not show up so markedly in the diffraction pattern due to the smaller scattering of silicon relative to oxygen. That vitreous SiO_2 and GeO_2 should have the same atomic arrangement and yet give quite different scattering patterns is due to the relative difference in the scattering power of the atoms.

III. Results on Other Glasses

Three other simple glasses, vitreous BeF_2, B_2O_3, and P_2O_5, are being studied by C. F. Hill of this laboratory. BeF_2 has the same atomic arrangement as vitreous SiO_2 and GeO_2, each Be being tetrahedrally surrounded by 4F, building up the same nonrepeating random network. The analysis of the B_2O_3 and P_2O_5 patterns is not yet completed.

A start has been made on the soda-silica series of glasses[5] by Mr. Loring and the author. Seven samples with progressively increasing soda content have been X-rayed. The diffraction patterns show a continuous variation with increase in the soda content. Starting with 100% SiO_2, there is a strong peak at $\frac{\sin \theta}{\lambda} = 0.12$, as mentioned above in the discussion of the silica pattern. As the soda content increases, this peak diminishes in intensity, and at the same time a new peak at about twice the angle gradually increases in intensity, the change in the patterns being perfectly continuous.

Representing the composition as $(SiO_2)_{1-x}$-$(Na_2O)_x$, the ratio of oxygen to silicon atoms becomes $O:Si = \frac{2-x}{1-x}$. Since x is less than unity, this ratio is necessarily greater than 2. Each silicon will still be tetrahedrally surrounded

[5] In this work, the author is indebted to G. W. Morey for his kind coöperation in preparing the various samples.

by 4 oxygens, but with the O:Si ratio greater than 2, it is necessary that only part of the oxygens be shared between two silicons. The other oxygens, which are bonded to only one silicon, will be the ones which are bonded to the Na-atoms. Hence the original set of inter-neighbor distances which determined the silica pattern become progressively of less importance and the first peak diminishes in intensity. At the same time a new set of distances, depending on the atoms surrounding any Na-atom, become more and more important. It is probably this

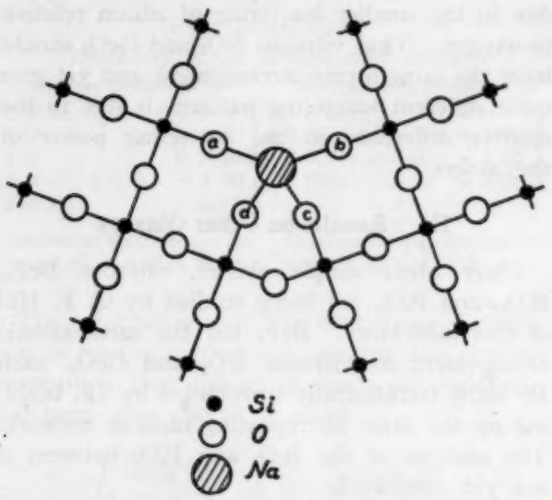


FIG. 4.—Schematic illustration of the atomic arrangement in a soda-silica glass.

new set of distances which is responsible for the peak at larger angle which grows in intensity with increasing soda content.

Figure 4 illustrates schematically the probable arrangement in a soda-silica glass. Each silicon is bonded to 4 oxygens (in 3 dimensions a tetrahedral arrangement, of course) and some of the oxygens are shared between 2 silicons. The other oxygens, such as *a*, *b*, and *c*, are joined to one silicon and 2 or 3 sodium atoms. It will probably be some time before the analysis of the soda-silica patterns is completed, but the results will certainly be of the greatest interest, for the atomic arrangement which is found will be essentially that of a typical glass.

IV. General Discussion

The agreement between the calculated and experimental X-ray scattering curves for the simple glasses is sufficiently satisfactory to allow one to consider the random network hypothesis of the glassy state as completely substantiated. The atomic arrangement and interatomic distances in a glass are practically the same as in the corresponding crystalline modifications, the essential difference being that the random network which is built up in a vitreous substance does not repeat at regular intervals, and hence the material is noncrystalline. It is just this point which differentiates the glassy from the crystalline state. The random network picture of the vitreous state, which has been deduced here from X-ray scattering results, is in complete agreement with the conclusions reached by Zachariasen[6] from other considerations.

There is no evidence for the existence of compounds in glass from any of the X-ray diffraction patterns so far analyzed. As long as the sample is a true glass, containing no devitrification products, the diffraction pattern consists solely of one or more diffuse rings, which are readily interpreted in terms of a random network.

Glass is a definite example of an amorphous solid. For thermodynamic reasons it is customary to refer to glass as an "undercooled liquid," the point being that this term implies the absence of a definite melting point. However, the term "amorphous solid" also implies just this, and since, in addition, the atoms in a glass do have permanent neighbors, which is a characteristic of the solid state, it might be preferable to classify glass as an "amorphous solid," although obviously in the sense in which the two terms are used here, "amorphous solid" and "undercooled liquid" mean exactly the same thing.

EASTMAN LABORATORY OF PHYSICS
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASS.

[6] W. H. Zachariasen, *Jour. Amer. Chem. Soc.*, **54**, 3841 (1932).

PYROMETRIC CONE-EQUIVALENT VALUES FOR THE CaO–Al_2O_3–SiO_2 SYSTEM*

By Frank Zvanut and Hewitt Wilson

ABSTRACT

A diagram and table were prepared showing the cone-equivalent values of the principal compositions in the lime–alumina–silica system for use in refractories, Portland cement, and metallurgical operations.

Data have been gathered to translate the theoretical melting temperature data of Rankin and Wright[1] and Bowen and Greig[2] into terms more common and useful to the ceramic engineer dealing with clay, kaolin, bauxite, diaspore, and silica refractories in contact with slags or products high in lime, such as Portland cement and basic open-hearth furnaces. The cone-fusion slag test has been found useful in predicting the pyrochemical reaction between slags and refractories.

There has always been some question about the direct translation of the temperatures obtained by the Geophysical Laboratory into cones of fusion or temperatures of softening obtained in the ceramists' kilns. The former are the temperatures obtained at the appearance of the first minute evidence of crystallization in the cooling of a hot liquid which has been carefully purified and rendered homogeneous by repeated meltings and pulverization. What connection has this with the softening or deformation of a poorly mixed, inhomogeneous batch of clay, flint, and calcium carbonate during the first heating when no attention is paid to crystallization but directed rather to the attainment of a certain degree of fluidity or softening of the partially melted mechanical mixture?

The principal compositions whose percentages were given in the Geophysical Laboratory reports were calculated in terms of Edgar Florida kaolin, potter's flint, and a commercial grade of precipitated whiting with pure alumina for compositions above the kaolin ratios.

The composition numbers and the oxide compositions given in columns 1 and 2 of Table I were taken from Rankin and Wright's calculations except in a few cases. The batches were ground together in a porcelain mortar, screened through a 65-mesh sieve and made into cones, using gum-arabic sorts as a binder when necessary. For fusions below cone 20, the cones were fired in a

Table I

Compositions, Melting Temperatures, and P.C.E. Values

Composition No.	CaO (%)	Al_2O_3 (%)	SiO_2 (%)	Melting temperatures (°C)	P.C.E. by calculation*	P.C.E. by experiment
1	9.8	19.8	70.4	1345	12–13	16
2	23.25	14.75	62.0	1170	3	7–8
3	53.0	4.2	42.8	1415	14–15	14–15
4	48.2	11.9	39.9	1335	12	11
5	38.0	20.0	42.0	1265	8–9	9
6	47.2	11.8	41.0	1310	10–11	11
7	29.2	39.0	31.8	1380	13–14	13–14
8	49.0	14.4	36.6	1415	14–15	9
9	15.6	36.5	47.9	1512	18–19	17
11	31.2	44.5	24.3	1475	17	15
12	37.5	53.25	9.25	1505	18–19	17–18
13	48.3	42.0	9.7	1380	13–14	14
14	49.5	43.7	6.8	1335	12	14
15	52.0	41.2	6.8	1335	12	14
16	58.3	33.0	8.7	1455	15–16	15
17	59.7	32.8	7.5	1470	16–17	15
18	68.4	9.2	22.4	1900	41	*
19	54.5	38.0	7.5	1390	13–14	14
20	48.7	39.3	12.0	1430	14–15	15
21	20.1	36.6	43.3	1550	20–23	19
22	40.8	37.1	22.0	1590	23–26	18–19
23	48.2	..	51.8	1540	20–23	20–23
24	58.2	..	41.8	1475	17	16
25	65.0	..	35.0	2130	Above 42	†
26	73.59	..	26.41	1900	41	†
27	62.22	37.78	..	1535	20–23	15–16
28	47.78	52.22	..	1455	15–16	15
29	35.44	64.56	..	1600	26–27	23
30	24.78	75.22	..	1720	32–33	30
31	..	72.0	28.0	1810	36	39
32	..	62.85	37.15	1865	39	39
33	..	40.0	60.0	1775	35	33
34	..	5.5	94.5	1545	20–23	32
35	..	10.0	90.0	1590	26	27–28
36	45.7	13.2	41.1	1316	10–11	10
37	51.3	41.8	6.9	1350	13	13
38	37.0	..	63.0	1436	15	15
39	55.0	..	45.0	1455	16	14–15
40	68.0	..	32.0	2065	Above 42	†
41	50.0	50.0	..	1395	13–14	14–15
42	47.0	53.0	..	1400	14	14
43	33.5	66.5	..	1590	23–26	20
44	24.0	76.0	..	1700	32	28–29
45	34.1	18.6	47.3	1299	9–10	9–10
47	49.6	23.7	26.7	1545	20–23	18–19
48	19.3	39.3	41.4	1547	20–23	19–20
49	35.0	50.8	14.2	1552	20–23	18
50	30.2	36.8	33.0	1385	13–14	13

* Using data from C. O. Fairchild and M. F. Peters, "Characteristics of Pyrometric Cones," *Jour. Amer. Ceram. Soc.*, **9** [11], 701 (1926).

† The melting temperatures for these cones were too high; the cones with very high lime content vaporized before melting temperature was reached.

*Received January 29, 1934.

[1] G. A. Rankin and F. E. Wright, *Amer. Jour. Sci.* [4], **39**, 1–80 (1915).

[2] N. L. Bowen and J. W. Greig, *Jour. Amer. Ceram. Soc.*, **7** [4], 238–54; [5], 410 (1924).

high-temperature load-test kiln at the rates shown in a previous article.[3] A modified type of the oxygen-acetylene furnace[4] described in 1921 was used for fusions above cone 20. The cones high in lime were set in plaques of iron-chromite but this precaution was not necessary with the more siliceous or aluminous compositions. Difficulty was experienced with many lime-mat glazes. The data obtained are given in Table I and Fig. 1.

The pyrometric cone equivalent data closely parallel the melting temperatures of this system. This similarity has been accentuated by the selection of the compositions tested at the quintuple and eutectic compositions as well as by the drawing of the "isocone" lines curved after the

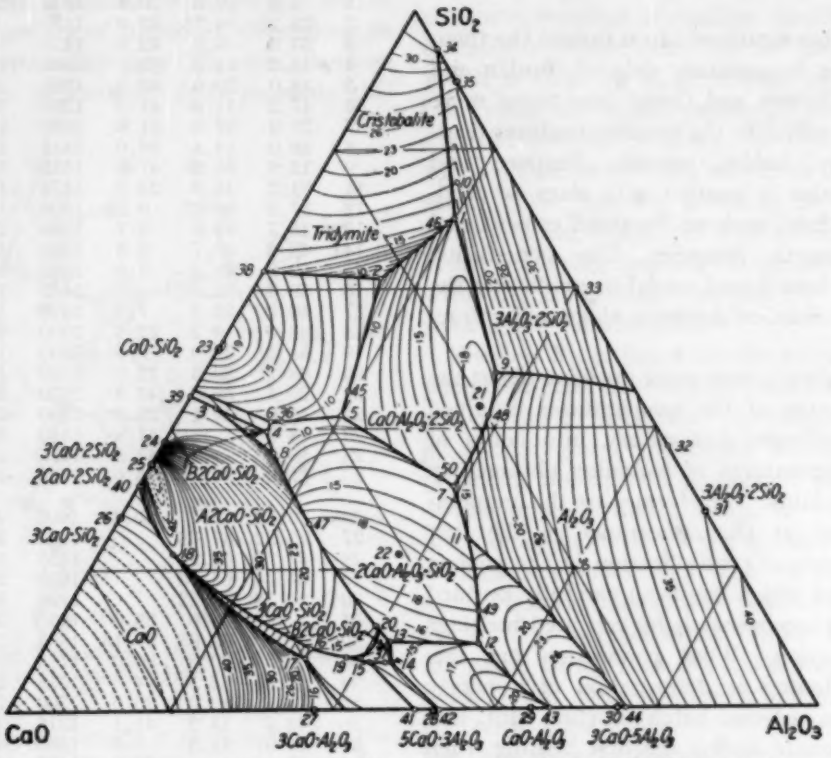


FIG. 1.—Pyrometric cone equivalent values for the CaO–Al_2O_3–SiO_2 system.

basic cones which squatted suddenly without giving the slow bending deformation of the standard Orton cones. Certain compositions, particularly in the gehlenite field gave a yellow-brown discoloration and this has also been noted in high fashion of the melting temperature concentration diagrams. The most important disagreement occurred at the eutectic for Al_2O_3–SiO_2 where the present data indicated better agreement with the original Seger eutectic obtained by cone fusion methods than with Bowen and Greig's melting temperature eutectic.

[3] Hewitt Wilson, "High-Temperature Load and Fusion Tests of Fire Brick from the Pacific Northwest," *Jour. Amer. Ceram. Soc.*, **7** [1], 36, 37 (1924).

[4] Hewitt Wilson, "An Oxygen-Acetylene High Temperature Furnace," *ibid.*, **4** [10], 835–41 (1921).

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF WASHINGTON
SEATTLE, WASHINGTON

QUANTITATIVE MICROSCOPIC DETERMINATION OF THE QUARTZ CONTENT OF COMMERCIAL GROUND FELDSPARS*

By C. L. Thompson

ABSTRACT

The literature on quantitative microscopic analyses is briefly reviewed. A variation in technique applied to fused feldspar samples is described. The results are compared with values obtained by calculation from the chemical compositions of the samples. The reproducibility of the results is demonstrated.

I. Introduction

A number of papers have appeared on the quantitative determination of the quartz content of feldspars by means of the petrographic microscope. The work upon which this paper is based was undertaken to determine the accuracy that could be expected from such determinations and to establish a desirable, simple technique.

II. Literature Review

All quantitative microscopic determinations are based on the determination either of the linear or areal extent of the constituents of the sample.

(1) Areal Measurements Delesse[1] was the first to demonstrate that the volume percentages of the mineral constituents of a rock could be determined from the areal proportions if sufficient areas were measured. He determined the areal extent of the constituents by tracing on tinfoil and weighing the foil. Various modifications and refinements of the method have been introduced in adapting the method to microanalysis. These include the use of the camera lucida, photographs, the polar planimeter, the cross-hatch eye-piece, and the planimeter eye-piece.

(2) Linear Intercepts In 1898, Rosiwal[2] demonstrated mathematically that the linear intercepts of the constituents of a sample are proportional to the volume and he determined the quantitative mineral composition of rocks by this method. The method is widely used and the measurements have been greatly simplified by the development of micrometer stages such as the Shand[3] and Wentworth.[4]

III. Determinations of Quartz in Feldspars

McCaughey[5] determined microscopically the mineral composition, including quartz, of crude feldspars. The sample was crushed and ground to pass a 100-mesh sieve. The grains of the various minerals were differentiated by their indices of refraction and the proportions determined by counting the grains.

NOTE: The technique requires that the grains be of rather uniform size and necessitates carefully standardized immersion oils. Even normal temperature changes that may occur in the laboratory change the index of the oil sufficient to require adjustment. The relief of the grains is so low and the incident eye strain so great that the method becomes very tedious and is subject to large personal errors, particularly when applied to commercially ground feldspars.

Booze and Klein[6] determined the quartz content of feldspars by comparing slides of the fused sample with samples of known quartz content.

NOTE: The fusion method developed by them has been found to be satisfactory for all but the high soda feldspars. The comparison method for determining the amount of quartz is not of high accuracy, however, and is subject to large personal errors.

Insley[7] determined the mineral composition of commercial ground feldspars by an adaptation of the method used by McCaughey[5] on lump feldspars. An oil having an index of refraction of 1.540 was used to distinguish between the quartz and the feldspars. The maximum variation of the values for quartz determined microscopically from those calculated from the chemical analysis was 5.3% of the weight of the total sample.

Insley[7] also determined the quartz content of the feldspars by a modification of the Booze and Klein[6] method. The samples were fused and thin sections prepared from the fusions. The linear intercepts of quartz and of feldspar glass were measured with the Wentworth stage micrometer. The values obtained did not check those calculated from chemical analyses quite as well as those obtained by counting grains.

At about the same time, Parmelee and McVay[8]

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (White Wares Division). Received February 14, 1934.

[1] A. Delesse, *Compt. rend.*, **25**, 544–45 (1847).

[2] A. Rosiwal, *Verhandh. k. k. Geol. Reichsanstalt*, p. 143 (1898).

[3] S. J. Shand, *Jour. Geol.*, **24**, 394 (1916).

[4] C. K. Wentworth, *ibid.*, **31**, 228 (1923).

[5] W. J. McCaughey, *Trans. Amer. Ceram. Soc.*, **15**, 381 (1913).

[6] M. C. Booze and A. A. Klein, *Jour. Amer. Ceram. Soc.*, **6** [6], 698 (1923).

[7] H. Insley, *Jour. Amer. Ceram. Soc.*, **10** [9], 651 (1927).

[8] C. W. Parmelee and T. N. McVay, "An Investigation of the Properties of Some Feldspars," *Univ. Ill., Eng. Expt. Sta. Bull.*, No. 233.

used an identical variation of the Booze and Klein method. The values reported show a maximum deviation from values calculated from chemical analyses of 2.0% of the weight of the total sample.

Malinovszky[9] determined the quartz content of fused feldspars from photomicrographs of the fusions. The details of the technique are not given.

IV. Technique Employed

In this work five commercially ground feldspars were used upon which accurate chemical analyses had been made. The feldspars were fused by the same procedure as recommended by Booze and Klein, *i.e.*, heated to cone 12 in about one and one-half hours and given a 15-minute soak at that temperature.

The fusions were sectioned and the quartz content determined by the linear intercept method as described by Insley[7] and by Parmelee and McVay.[10] It was found that values comparing favorably with those calculated from chemical analyses were obtained if sections of unusual thinness could be obtained, but that the values for quartz content tended to be too high even when determined on sections of usual thickness (0.03 millimeter). This difficulty and a desire to simplify the method led to the abandonment of the thin sections.

The fusion, prepared as before, was crushed, ground in an agate mortar, and screened through a 200-mesh sieve. Sieving was resorted to frequently to prevent production of excessive fines, and the grinding was continued until all of the sample passed through the sieve.

The ground sample was mixed thoroughly and a portion of it examined in an oil, having an index of refraction of 1.528. In this oil it is very easy to distinguish between the feldspar glass and the quartz. The former has a decidedly lower index of refraction while the indices of the quartz are appreciably higher than the oil. Considerable variation in the index of refraction of the oil from the value used is possible without serious loss of relief of the grains.

The linear intercepts of the grains of quartz and feldspar glass were determined with a Wentworth stage micrometer using a magnification of 380 diameters. Three or four traverses were made across at least five different slides. The volume percentages calculated directly from the linear intercepts were changed to weight percentages using 2.37 as the specific gravity of the feldspar glass and 2.65 as the specific gravity of quartz. About two hours are required to measure sufficient intercepts.

V. Results

The results obtained are given in Table I. Triplicate determinations were made on samples 2 and 5 to test the reproducibility of the results.

TABLE I

QUARTZ CONTENT OF FELDSPARS

(microdeterminations)

Feldspar No.	Using thin section (%)	Using Powders (%)			Chemical analysis* (%)
		1	2	3	
2	13.0	12.2	11.3	11.3	11.9
5	6.0	4.1	4.7	4.8	4.6
6	9.4	7.4			7.4
7	15.0	15.0			14.5
10	14.7	13.2			14.4

* Calculated by kaolinite method, Insley, *loc. cit.*

VI. Discussion

The technique described gives surprisingly accurate results. The maximum variation from the value for quartz content calculated from the chemical analyses is 1.2% of the weight of the sample and 11% of the quartz content; the average variation is less than 0.5% of the weight of the total sample and less than 5.0% of the weight of the quartz. The technique is simple and rapid, the use of a thin section has been eliminated, and the entire determination, including the fusion of the sample, can be made in four hours.

DEPARTMENT OF CERAMIC ENGINEERING
UNIVERSITY OF ILLINOIS
URBANA, ILLINOIS

[9] A. Malinovszky, *Jour. Amer. Ceram. Soc.*, **10** [1], 23 (1927).

[10] C. W. Parmelee and T. N. McVay, *loc. cit.*; the numbers used in their paper are the same as used in the present work.

CERAMIC ABSTRACTS[1]

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Sawing of metals. E. Kurz. *Maschinenbau (Der Betrieb)*, **13** [1–2], 39–40 (1934).—A brief general discussion is given. Bibliography. (*B.B.N.F.M.R.A.*)

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Abrasive device. J. L. Ballash (Sterling Grinding Wheel Co.). U. S. 1,962,947, June 12, 1934.

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Bread knife grinding machine. Angus McMillan. U. S. 1,961,504, June 5, 1934.

Expansible abrading tool. J. E. Sims (Joseph Disco). U. S. 1,960,555, May 29, 1934.

Grinding machine. R. H. Cramer (General Motors Corp.). U. S. 1,960,730, May 29, 1934.

Grinding machine. W. F. Fraser (Norton Co.). U. S. 1,961,849, June 5, 1934.

Grinding machine. W. A. Goering (Safety Grinding Wheel & Machine Co.). U. S. 1,962,302, June 12, 1934.

Machine for grinding friction elements. H. N. Smith (American Brakeblock Corp.). U. S. 1,961,175, June 5, 1934.

Polishing or abrading materials. Fritz Simon. Ger. 580,206, Dec. 18, 1933. A mixture of emery or like material and powdered resin is applied to a paper or fabric support which has been coated with a drying oil or varnish. Alternatively or in addition, powdered resin is dusted on to the support directly after the emery has been applied. The support is then warmed. (*C.A.*)

Polishing, grinding, and sharpening material. Siemens & Halske A.-G. (Reinhold Reichmann, inventor). Ger. 589,374, Dec. 6, 1933; Fr. 755,790, Nov. 30, 1933. Practically pure BeO which has been sintered at above 1700° is used for polishing, grinding, and sharpening very hard materials such as hard alloys. (*C.A.*)

[1] The bold-face number following the journal is the volume, the issue number is in brackets, followed by the page numbers, then the year in parentheses.

Truing device for abrasive wheels. G. J. SUTTON (Percy Nuckey and R. J. Scott). U. S. 1,960,760, May 29, 1934.

Valve grinding tool. ARTHUR OLSEN. U. S. 1,959,838, May 22, 1934.

Art and Archeology

Age of the British flint mines. GRAHAME CLARK AND STUART PIGGOT. *Antiquity*, **7** [26], 166–83 (1933).—Pottery found in flint mines compares with neolithic pottery of the Windmill Hill class. Another type called "Chocolate" ware is also found. A.A.A.

Ancient glass. D. B. HARDEN. *Antiquity*, **7** [28], 419–28 (1933).—A review of the history of glassware from its beginning to the end of the Roman period is given. A.A.A.

Ancient and medieval pottery, a résumé. II. LAURA B. CAMPBELL. *Ceram. Ind.*, **22** [6], 315–17 (1934).—The tradition regarding the origin of majolica is cited. Lustered ware only was first designated by the Italians as majolica, though now the name is applied to all the Italian enameled pottery of the 15th Century. Majolica ware was first manufactured in France in 1590, and later was introduced into Germany; much beautiful ware was made at Nuremburg. The Persian potters understood the art of producing lustered ware. When the Moors invaded Spain, due to a knowledge of the art of glazes and enamel transmitted to them by the Persians, they were able to introduce a glazed tile of many colors into Spain, and later Hispano-Moorish pottery was developed. Several classes of Spanish ware are discussed. A history of the discovery of kaolin and the production of porcelain is presented, discussing some outstanding examples of beautiful porcelain ware. At the beginning of the 13th Century, Holland began the production of salt-glazed stoneware. Delft produced a glazed ware that was beautiful and decorative in effect, especially that in blue and white. Germany and Flanders followed Holland in the production of beautiful stoneware. Illustrated. For Part I see *Ceram. Abs.*, **13** [7], 168 (1934). E.J.V.

Applications of glass in mosaics. M. DEBOURLE. *Céram., Verrerie, Email.*, **1** [7], 347–49 (1933).—Glass and enamels offer large decorative possibilities in mosaics due to the durability of the materials and colors and the wide variety of colors in use. Care must be taken in construction to allow for expansion. See also "Glass mosaic," *Ceram. Abs.*, **13** [4], 86 (1934). M.H.B.

Belgic cities of Britain. R. E. M. WHEELER. *Antiquity*, **7** [25], 21–35 (1933).—Large masses of wheel-made pottery were found in excavations, thick gritty ware and smooth gray or black ware. It is supposed to be pre-Augustan and not Italian. A.A.A.

Cadmium yellow and cadmium red as ceramic pigments. LUDWIG STUCKERT. *Farben-Ztg.*, **39**, 9–10, 36–38, 61–63 (1934).—The literature of CdS and CdSe is briefly reviewed. CdS, prepared by precipitation of soluble Cd salts with H_2S, while suitable as such in ceramics is unsuitable for the preparation of CdSe. For this purpose, CdS is best prepared by reaction of suspended $CdCO_3$ with Na_2S or NaSH. The completeness of this reaction and the effect of conditions upon the particle size of the product were studied. CdS, prepared by the direct dry method, consists of mixed crystals of α- and β-CdS in various ratios. Cadmium red can be prepared by reaction of a suspension of $CdCO_3$ with a solution of Se in Na_2S or $(NH_4)_2S$. A thioselenide is formed, which, when heated, loses S and rearranges to form a bright red pigment. In the direct preparation of cadmium red by heating $CdCO_3$, S, and Se, a brown mixture of sulfides and selenides is formed at about 300°. This mixture decomposes endothermally at 450 to 650° into a light red pigment. (*C.A.*)

I. C. I. standard observer and coördinate system for colorimetry (1931). DEANE B. JUDD. *Jour. Opt. Soc. Amer.*, **23** [10], 359–74 (1933).—The properties of the standard observer recommended for colorimetric purposes by the International Commission on Illumination are presented. Transformation equations are given to the previous O. S. A. coördinate systems. Forms are worked out for computing trilinear coördinates (trichromatic coefficients), dominant wave-length, colorimetric purity, and luminous transmission (reflectance) from spectrophotometric data. Tables of the data needed are included for the 1931 I. C. I. standard illuminants A, B, and C. R.H.H.P., JR.

John Turner and the Bristol figure molds. FRANK TILLEY. *Connoisseur*, **93** [394], 390–91 (1934).—T. discusses the identification of the Champion molds of the figures "The Elements" as used by John Turner. Illustrated. E.B.H.

Neolithic age in northern China. CARL WHITING BISHOP. *Antiquity*, **7** [28], 389–404 (1933).—Pottery fragments occur in large quantities on Chinese sites. Complete vessels were usually found only in association with burials. Polychrome ware and a fine black ware are characteristic of northeastern China. A.A.A.

Palatinate ceramics. CHARLOTTE STEINBRUCKER. *Sprechsaal*, **67** [16], 235–36 (1934).—A brief historical review is given of the achievements in the field of the ceramics of the Palatinate. M.V.K.

Richard Askew, painter of ceramics. WILLIAM H. TAPP. *Connoisseur*, **93** [394], 359–63 (1934).—The article is a history of the work of Richard Askew, with illustrations of several pieces. Characteristics are black eyes, red lips and nostrils, Chelsea foliage (each tree or leaf washed in with a neutral color and the extremities brushed over with darker color at the next firing), tousled black hair, crimson blouses or sashes, green-yellow washes somewhere, cupids often anatomical monstrosities, clouds and shading done by a wash over stippling. He was of the 18th Century. E.B.H.

Salt-glazing at cone 02 by slip application. MARION L. FOSDICK. *Jour. Amer. Ceram. Soc.*, **17** [7], 219–20 (1934).

Two Athenian vases. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **29** [4], 70 (1934).—A black-figured column krater dated about 530 B.C. whose glaze has assumed interesting black, greenish black, and red colors and a white lekythos of fine workmanship are gifts of the late Julius Sachs. A.A.A.

Two faience aryballoi. G. M. A. RICHTER. *Bull. Met. Mus. Art*, **29** [5], 81 (1934).—Two blue-glaze faience aryballoi recently placed in the Second Classical Room are a striking contrast to other Greek vases. These brilliantly

colored glazes were made during the late 17th Century B.C. and early 6th Century and do not appear again until the days of the early Roman Empire. A.A.A.

BOOKS

Attic Vase Painting. C. P. SELTMAN. xviii + 97 pp., 37 plates. Harvard Univ. Press, 1934. Price $1.50. Reviewed in *Times Lit. Supp.*, **33**, 127 (1934). H.H.S.

Corpus Vasorum Antiquorum: United States: University of Michigan: Fascicule I. WILHELMINA VAN INGEN. 84 pp., 48 plates. Harvard Univ. Press, 1934. Price $5.00. Reviewed in *Times Lit. Supp.*, **33**, 127 (1934); see also *Ceram. Abs.*, **10** [12], 822 (1931). H.H.S.

Tell Halaf (Der Tell Halaf). MAX V. OPPENHEIM. F. A. Brockhaus, Leipzig. 276 pp., 131 illustrations. 14 Rm. bound, 12 Rm. unbound. Reviewed in *Keram. Rund.*, **42** [3], 34–35 (1934); see also *Ceram. Abs.*, **12** [10–11], 353 (1933). M.V.K.

PATENTS

Coloring ceramic materials. G. H. BROWN (Metal & Thermit Corp.). U. S. 1,960,329, May 29, 1934. In the process of manufacturing ceramic materials varying in color from full-toned ivory to a tan and free from red nuances, the step comprises adding to the ceramic materials as a tinting agent prior to firing a prefired mixture of native rutile with a small proportion of a zirconium compound, the mixture being added in proportions ranging from about 0.25 to 15% by weight.

Decorative spraying machine. F. C. FLINT AND C. B. WILES (Hazel-Atlas Glass Co.). U. S. 1,959,711, May 22, 1934.

Designs for:

Bottle. A. M. CLARK (Whitall Tatum Co.). U. S. 92,338, May 29, 1934.

Bottle. W. R. LEACH (Carr-Lowrey Glass Co.). U. S. 92,413, June 5, 1934.

Bottle. W. A. NESTER (Obear-Nester Glass Co.). U. S. 92,486, June 12, 1934.

Bottle. O. C. NOBLE (Tygart Valley Glass Co.). U. S. 92,364, May 29, 1934.

Bottle. SIDNEY PICKER (Crystal Corp.). U. S. 92,426, June 5, 1934.

Bottle. RICHARD RATNER (Republic Distillers, Inc.). U. S. 92,491 and 92,492, June 12, 1934.

Bottle. F. W. ROFFEY (Melchers Distilleries, Ltd.). U. S. 92,493, June 12, 1934.

Bottle. N. F. STEUER (Owens-Illinois Glass Co.). U. S. 92,501, June 12, 1934.

Bottle. C. B. STEVENS (Holsum Products, Inc.). U. S. 92,436, June 5, 1934.

Flowerpot. G. W. PFALTZGRAFF (Pfaltzgraff Pottery Co.). U. S. 92,314, May 22, 1934.

Jar. E. C. DAY (Owens-Illinois Glass Co.). U. S. 92,391, June 5, 1934.

Jar. E. W. FUERST (Owens-Illinois Glass Co.). U. S. 92,339 and 92,340, May 29, 1934.

Jar. HENRY GUITTON (Owens-Illinois Glass Co.). U. S. 92,397, June 5, 1934.

Jar. T. J. PIAZZOLI (Capstan Glass Co.). U. S. 92,423 and 92,424, June 5, 1934.

Jar. SIDNEY PICKER (Crystal Corp.). U. S. 92,425, June 5, 1934.

Lighting fixture bowl. E. L. BRADBURY (Gillinder Bros., Inc.). U. S. 92,286, May 22, 1934.

Plate. KARL HIPPMANN (Rosenthal China Corp.). U. S. 92,307, May 22, 1934.

Plate. GEORGE WESP (Continental Ceramics Corp.). U. S. 92,381, May 29, 1934.

Range. E. D. PELLEGRIN (Cribben & Sexton Co.). U. S. 92,490, June 12, 1934.

Stove. C. L. HARDWICK. U. S. 92,298 and 92,299, May 22, 1934.

Process for coloring the surface of unglazed fired brick, tile, earthenware, etc. A. L. MOND (I. G. Farbenind. A.-G.). Brit. 410,651, May 30, 1934.

Production of lead glazes. H-J. HARKORT. Brit. 410,602, May 30, 1934.

Cements

Alkalis in the system Portland cement–water. TUTOMI MAEDA AND RYUZO SYOZI. *Sci. Papers Inst. Phys. Chem. Research*, **24** [498], 49–55 (1934) (in Esperanto).—The constitution of the liquid phase in equilibrium with a mix of 2 parts cement and 1 of water after 2 hours at 25°C was studied for 5 Japanese Portland cements. A linear relation was found between the total alkali in the liquid and the concentration of Ca^{++}, SO_4^{--}, and $Na^+ + K^+$. For one mix (cement to H_2O, 1:0.4) after 48 hours at 50°C, 90.4% of the original alkali was in solution in the form of hydroxides. J.B.A.

Diatomaceous earth. Equilibrium and rate of reaction in the system lime–diatomaceous silica–water. A. B. CUMMINS AND L. B. MILLER. *Ind. Eng. Chem.*, **26** [6], 688–93 (1934).—The conditions of equilibrium and of the rate of reaction in the system lime–diatomaceous silica–water, with diatomaceous silica present in excess, are studied. At equilibrium the liquid phase contains silica and lime in solution in the molecular ratio of 1.5. This corresponds to the formula $2CaO{\cdot}3SiO_2$. The solid phase under these conditions consists of unreacted diatomaceous earth and, presumably, of a hydrated calcium silicate. The latter has a molecular ratio of silica to lime of 1.2 corresponding to the formula $5CaO{\cdot}6SiO_2$. The rate of reaction between diatomaceous silica and lime solution is characterized by rapid reaction during the first few minutes. This is followed by a "period of inhibition" during which the rate of reaction over a period of several hours is relatively low. A period of higher rate of reaction which continues to equilibrium then follows. Many grades of diatomaceous earth are included in these studies, and samples of bentonite, a highly colloidal claylike material, tripoli, a cryptocrystalline form of silica, and 200-mesh quartz are included for comparison. The effects of fineness and of calcination of the various materials at 1800°F upon the rates of reaction of the materials with lime are studied. The effectiveness of the various materials in increasing the workability of concrete is presented in the form of per cent improvement in workability. The latter data are obtained by means of the penetration work-

ability apparatus developed at the Bureau of Standards. Applications of the many data obtained are indicated. Illustrations, photomicrographs, and curves are included. F.G.H.

Liquid phase of Portland cement in practical mixing proportions. T. MAEDA AND R. SYOZI. *Sci. Papers Inst. Phys. Chem. Research*, **23** [478], 137–52 (1933) (in Esperanto).—The liquid phase was extracted from cement mixes by a high pressure ultrafilter and by a hand press. With mixtures containing 27, 40, 50, and 60% H_2O, in the early stages of hardening at 25°C the concentration of SO_4^{--} Na^+ and K^+ is greater with smaller amounts of water while that of Ca^{++} is less. In a 50:50 cement-H_2O mix the alkalinity due to alkali-metal hydroxide in the liquid phase is rather large. The alkali-metal compound in one cement gave up all its alkali to the solution in about three weeks. J.B.A.

Setting of Portland cement. Chemical reactions and the rôle of calcium sulfate. P. S. ROLLER. *Ind. Eng. Chem.*, **26** [6], 669–77 (1934).—Analyses of the liquid phase and time-of-set tests have been made for three cements and for several clinkers under different conditions of added reagent and of seasoning. A technique was developed for extracting the liquid phase from the plastic cement mass and the former was then analyzed microchemically and by other means. Illustrated. F.G.H.

PATENT

Process of producing cementitious material. C. A. HOGGATT (Certain-Teed Products Corp.). U. S. 1,960,538, May 29, 1934. The process of manufacture of calcined gypsum comprises calcining gypsum to produce a product retaining a part of the water of crystallization and capable of setting and adding to the gypsum before completion of the calcining operation a water-soluble alkali compound containing a halogen.

Enamels

American enamel for Persian rug store. ANON. *Amer. Enameler*, **7** [2], 14 (1934).—Porcelain enamel, the most modern building material, is used in reproducing a 300-year old store of Teheran, Persia. H.T.

Analysis of cryolite. ANON. *Amer. Enameler*, **7** [2], 5 (1934).—The prescribed method for the analysis of cryolite in determining its suitability for use in high-grade porcelain enamels is given. H.T.

Behavior of iron oxide in the presence of titanium oxide in the enamel. JAMES S. LEW. *Sprechsaal*, **67** [15], 215–16 (1934).—The behavior of iron oxides in silicate melts is discussed on the basis of the latest researches. The catalytic effect of titanium oxide on the behavior of iron oxide in the enamel and the mechanism of the yellow coloring of the enamel opacified with titanium oxide are dealt with. Bibliography. M.V.K.

Bursting of enameled cooking utensils. RICHARD ALDINGER. *Keram. Rund.*, **42** [8], 93–96 (1934).—After discussing the opinions of various authorities on the cracking of enameled cooking ware, A. describes the processes taking place in the enameled ware during heating and the tensions and stresses occurring in it. The bursting of the coating enamel in cooking ware depends to a certain degree on the thickness of the sheet iron and the thickness of the enamel layer. The formation of networks of fine cracks on the enamel is discussed. The testing of enamel for its suitability for cooking ware is described. Illustrated. See also *Ceram. Abs.*, **13** [7], 171(1934). M.V.K.

Cleaning and pickling of sheet iron for enameling. W. FRÖLICH. *Emailwaren-Ind.*, **11** [13], 114–15 (1934); abstracted in *Verre & Silicates Ind.*, **5** [8], 155 (1934).—Oily deposits are removed by K_2CO_3. Sodium salts are cheaper, but their effect is 3 to 4 times slower and the rinsing of the ware is more difficult. Deposits of mineral oils are eliminated by emulsion; caustic soda is recommended (not the carbonate). Mixtures containing 50% Na_3PO_4, 35% Na_2CO_3 (calcined), 10% NaOH, and 5% soap can be used with success for eliminating the sticking sand from polishing. Soaps of fatty acids are preferable in this case; ware cleaned with linseed oil soap are easily rinsed. Lacquered sheet iron is difficult to clean; a good mixture is 80% NaOH, 15% Na_2CO_3, 5% resin. Resin soaps clean well. Very soiled and oxidized sheet iron must be treated by blasting or by a heated acid solution or heated to 350° before soaping. The best results are obtained by blasting followed by alkaline cleaning. The latter is more efficient at 80° and when continued for 15 or 20 min. M.V.K.

Composition of enamel. L. VIELHABER. *Emailwaren-Ind.*, **11** [16], 137–49; [17], 145–49 (1934).—A detailed discussion is given of the properties of separate ingredients of the enamel and the composition of ground enamel for sheet iron, cooking utensils, shields, and hearths, mixed ground enamel, and cast-iron ground enamel. M.V.K.

Development of a continuous vitreous enameling furnace. F. S. MARKERT. *Enamelist*, **11** [8], 12–18 (1934).—The various types of furnaces used for vitreous enameling from the latter part of the 19th Century to the present day are listed and described, *viz.*, the full muffle type, the semi-muffle furnace, and the intermittent-fired, modern box-type, continuous, and semicontinuous types. The hearth-conveyer and slotted-roof features of the continuous and semicontinuous types are described. A newer development is the counter-flow furnace, with a double firing chamber. Objections to each of these types of furnaces are pointed out as reasons for developing a better continuous enameling furnace. Illustrated. E.J.V.

Dissociation pressure of cobalto-cobaltic oxide. M. WATANABE. *Sci. Rept. Tôhoku Imp. Univ.*, **23** [1], 89–102 (1934).—The dissociation pressure of the cobalto-cobaltic oxide, Co_3O_4, was investigated at 855, 897, 928, and 960°C. The statical method was used. Thermodynamic values were calculated from these data. W.M.C.

Electric enameling kiln. E. FR. RUSS. *Sprechsaal*, **67** [17], 247–49 (1934).—After discussing advantages in using electrically heated enameling kilns, R. describes several types and compares their performance and operation with coal-fired kilns. M.V.K.

Enamel shop troubles. J. ATKINSON. *Clay Prod. News*, **7** [5], 6 (1934).—A. describes several problems met in the enamel shop and the methods used to correct them. A.J.M.

Enamel as surface protection. R. ALDINGER. *Glashütte*, **64** [5], 72–74 (1934).—The properties of the enamel, its melting point, resistance to acids and lyes, hardness, luster, and color are great advantages over all other kinds of protective coatings. M.V.K.

Enameling in European countries. F. G. JAEGER. *Enamelist*, **11** [8], 19–20 (1934); see "Ankarsrum's bruk," *Ceram. Abs.*, **13** [7], 171 (1934). E.J.V.

Evaluating opacifiers in industry. L. VIELHABER. *Emailwaren-Ind.*, **11** [13], 113–14 (1934).—The necessity of testing and experimenting with new opacifiers before using them is discussed. The valuation of opacity is difficult. M.V.K.

Heat of reaction in the transformation austenite-martensite. H. ESSER AND W. BUNGARDT. *Arch. Eisenhüttenwesen*, **7**, 533–36 (1934).—The heat of reaction was investigated in the temperature range 300 to 900°C for the following substances: silver, an iron-manganese alloy containing 20% manganese, and three non-alloyed steels containing 0.5, 0.8, and 1.4% carbon, respectively. A water calorimeter was used. The heat of reaction of the transformation austenite-martensite was determined from the temperature-heat content curve of non-alloyed steels. The fact was taken into consideration that, on quenching, part of the austenite will remain stable. The austenite content will amount to 2% in steel below the eutectic composition; eutectic steel quenched at 750°C will show 8% austenite, and quenched at 1000°C, only 6%. Steel above the eutectic composition will contain from 6 to 25% in the same range of quenching. The heat of reaction of the transformation austenite-martensite amounts to 13.6 cal./g. in a steel containing 0.5% carbon, and to 11.4 cal./g. in a steel containing 1.4% carbon. W.M.C.

Immersing powder enamels. H. J. KARMAUS. *Sprechsaal*, **67** [6], 79–80 (1934).—Directions for applying powder enamels by immersing the ware in the powder enamel are given. A ground enamel and several coat enamels are given and analyzed. M.V.K.

Mechanics of enamel adherence. IX. Equilibrium studies in some systems of enamel glass and cobalt, nickel, and iron oxides. G. H. SPENCER-STRONG AND R. M. KING. *Jour. Amer. Ceram. Soc.*, **17** [7], 208–14 (1934). **X. "Iron oxide layer" in sheet-steel ground coats.** R. M. KING. *Ibid.*, **17** [7], 215–19 (1934); for Part VIII see *Ceram. Abs.*, **12** [7], 254 (1933).

Porcelain enameling of copper presents commercial possibilities. H. E. SIMPSON, J. D. SULLIVAN, AND G. A. BOLE. *Ceram. Ind.*, **22** [6], 300–303 (1934); see *Ceram. Abs.*, **12** [7], 255 (1933). E.J.V.

Porcelain enameling in 1940. R. A. WEAVER. *Better Enameling*, **5** [5], 13 (1934).—W. points out that the porcelain-enamel industry must compete directly with a number of metals and finishes and indirectly with every item the consumer might buy instead of an article finished in porcelain enamel. Continued coöperation and educational work is necessary for porcelain enamel to maintain its position in the future. The ground work has been done by the Porcelain Enamel Institute. E.J.V.

Porcelain enamels specified. ELECTRIC HOME AND FARM AUTHORITY OF T.V.A. *Amer. Enameler*, **7** [2], 4–5 (1934).—Abstracts from the concrete specifications on electrical refrigerators and ranges to be financed by the government under the T.V.A. are given. The specifications lay stress on the fact that only porcelain-enamel ranges and refrigerators sold below the frost line and coastal region will be financed through the T.V.A. Photographic proof of the durability of porcelain enamel is shown. H.T.

Redesigning an electrical layout to accommodate porcelain enameling. ANON. *Enamelist*, **11** [8], 21–24 (1934).—A detailed description of the electrically equipped small but efficient porcelain enameling plant installed by Fairgrieve & Son, Ltd., Toronto, Canada, for porcelain enameling washer tubs is given. Illustrated. E.J.V.

Review of the latest technical development in enamel operation. H. J. KARMAUS. *Emailwaren-Ind.*, **11** [14], 121–26 (1934); abstracted in *Sprechsaal*, **67** [12], 167–68 (1934); *Keram. Rund.*, **42** [12], 145–46 (1934).—The use of lepidolite is discussed. According to a patented method, the mineral is finely ground, treated with water, applied on the raw ware to be enameled, and fired to 1000°, producing a completely opaque and highly lustrous enamel layer solidly adhering to the iron. To change some properties of the enamel as needed, especially the coefficient of expansion, additions of not more than 30% silica, alumina, soda, lime, potash, etc., can be made. Two new products are used to improve suspension: (1) "Alugel" added to the mill with clay improves the ease of application and increases its opacity and color tone; (2) "Ultra-Sil" opacifying strongly has been substituted for clay with the same effects. New pigments are cadmium yellow and cadmium red. A new sheet iron is called "crystal etched." A new method for producing tin oxide has been developed. Among new contrivances for enameling are a patented firing kiln and a powder table. Enameling methods, such as gas opacification and obtaining marbled, spotty, and variegated enamels are briefly discussed. The addition of metallic silicon, silicides of heavy metals, or silicon carbide to the enamel, avoiding the formation of stresses and improving the thermal properties of the enamel, special firing in a channel kiln to increase the opacification of white enamel, and a photoelectric reflection and illuminating apparatus for measuring the luster and opacity of enamel are dealt with. See also *Ceram. Abs.*, **12** [10–11], 357 (1933). M.V.K.

Review of some metallurgical methods of analysis. I. H. J. KARMAUS. *Emailwaren-Ind.*, **11** [6], 50–51 (1934).—The silicon determination in cast iron is based on the dissolving of the sample in a solution possessing an oxidizing effect to make the silica insoluble. Details are given. M.V.K.

Significance of analysis with regard to the capability of enameling of cast iron. A. KRAÜTLE. *Emailwaren-Ind.*, **10** [14], 109–13 (1933).—This is the original reference; for abstract see *Ceram. Abs.*, **13** [1], 4 (1934). M.V.K.

Transformation of ferrite. E. AMMERMANN AND H. KORNFELD. *Arch. Eisenhüttenwesen*, **7**, 567–70 (1934).—According to Northcott (see following abstract) the α-transformation represents the formation of very small precipitates of ferrous oxide. It is assumed now that the α-transformation is identical with a change of boundaries between crystals of a similar orientation. Precipitates will play a rôle in this transformation, however, in the same way as found in other crystal boundaries. W.M.C.

Veining or sub-boundary structures. L. NORTHCOTT. *Jour. Iron Steel Inst.*, **126**, 267–87 (1932).—Veining network has been observed in mild steel, wrought iron, nickel, and copper as cast, but not in electrolytically deposited iron, nickel, or copper. Methods for inducing and removing veining are described. It is shown that veining is a result of the solid solubility of the oxide in the metal decreasing with decreasing temperature. The possible influence of oxygen upon aging is discussed.

Water added to enamel. L. VIELHABER. *Emailwaren-Ind.*, **11** [13], 116–17 (1934); abstracted in *Verre & Silicates Ind.*, **5** [8], 155 (1934).—Any kind of drinking water can be added to the mill. If it is hard water, however, the enamel is no longer usable after five days. Water containing organic impurities must be filtered. Chlorides in water are very injurious. M.V.K.

What the jobbing shop can do to increase its business. R. G. CALTON. *Better Enameling*, **5** [5], 9–10 (1934).—C. offers many constructive suggestions resulting from his experience with costs and plant management in the enameling industry. E.J.V.

What the public does not know about porcelain enamel. WILLIAM HOGENSON. *Better Enameling*, **5** [5], 11–12 (1934).—Stressing the need for educational and promotional effort on the part of the porcelain enamel industry, H. gives examples of the popular misconceptions held by the public and the general layman regarding porcelain enamel. Changing conditions require that the old attitude be changed and advertising and promotional effort must be put forth. E.J.V.

X-ray investigations of enamel melts. G. WIEDMANN AND W. MIALKI. *Z. tech. Physik*, **15** [4], 150–51 (1934).—Sodium, calcium, and aluminum fluorides or double fluorides, such as cryolite, chiolite, and sodium silicon fluoride may be added to enamel melts. Former microscopic and X-ray investigations of the cloudiness of enamels caused by the addition of fluorides are reviewed. The most probable explanation is that fluorides are precipitated while the rest of the melt remains in the amorphous state. The relation of cloudiness was studied as to the type of fluoride precipitated, composition and thermal treatment of the melt, and firing. A sodium borosilicate glass of the following formula was used: SiO_2 39.8, B_2O_3 11.2, Na_2O 29.1, fluoride 19.9%. The influence of temperature on the conversion from calcium fluoride to sodium fluoride was studied. The ratio CaF_2 to NaF will become higher with an increasing temperature of the melt and an increasing duration of melting. Calcium fluoride may be formed alone under special conditions. X-ray patterns were taken of the products of sublimation, and the pictures reduced photometrically. Melts containing sodium fluoride show a sublimation of pure NaF. Melts containing 30% calcium fluoride will show, besides CaF_2, a new precipitate, the amount of which increases with an increasing duration of melting. The new precipitate may be wollastonite. W.M.C.

PATENTS

Ceramic coated articles. W. J. SCOTT (Western Electric Co., Inc.). U. S. 1,962,751, June 12, 1934.

Enamel. IGNAZ KREIDL. Ger. 585,832, Oct. 11, 1933. Fe enamel or the white background of Fe enamel is prepared by coating the Fe with a solution or pseudo solution of salts or compounds of Ni or Co with nonvolatile acids in H_3PO_4. Preferably, H_3PO_4 solutions of phosphates or borates of Ni or Co or colloidal oxides or hydroxides of Ni or Co are used. (*C.A.*)

Enameling apparatus. W. T. CHRISTMAN AND HERBERT DEAN (Carborundum Co.). U. S. 1,962,635, June 12, 1934.

Enameling iron. LEICHTMETALL-VERWERTUNGS-GES. M.B.H. Ger. 585,409, Oct. 3, 1933. Sheet iron is coated with an aqueous sludge of natural lepidolite and then fired at 1000°. Up to 30% of SiO_2, Al_2O_3, CaO, MgO, K_2CO_3, or Na_2CO_3 may be mixed with the lepidolite. Preliminary application of a ground enamel is unnecessary. (*C.A.*)

Enamels. IGNAZ KREIDL. Fr. 754,524, Nov. 8, 1933. Slips, for making enamels, that are stable to storing are made by using opacifying agents, the necessary amount of which is not above the amount which can be absorbed by the slip. Suitable agents are organic dyes such as methylene blue and malachite green or highly polymerized hydrocarbons, such as resins, tars, and asphalts. The stability can be increased by the addition of an adsorption agent. (*C.A.*)

Manufacture of enamelware. J. E. ROSENBERG (Enamelers Guild, Inc.). U. S. 1,962,617, June 12, 1934. The method herein described of preparing a steel surface for the reception of an enamel coating consists in spreading upon the surface a liquid suspension of finely ground cobalt oxide together with clay, driving off the suspending liquid, and leaving upon the surface a residual film of the suspended material.

Production of white clouded enamel and glazes. I. KREIDL. Brit. 409,597, May 9, 1934.

Vitreous enamel frit and method of producing. C. J. KINZIE (Titanium Alloy Mfg. Co.). U. S. 1,959,678, May 22, 1934. In the method of producing a frit for acid-resisting vitreous enamels, the steps comprise separately premixing finely divided titanium compounds with part of the fusible enamel ingredients to form a mixture pulverized to about 100-mesh, the titanium content being from 32 to 42% of the mixture, adding this mixture so formed to a raw batch of enameling materials in the proportion of about 1:4, and then smelting the charge to form the enamel frit.

Glass

Acetate film for safety glass. ANON. *Brit. Plastics*, **5** [60], 564 (1934).—An outline is given of the advantages of cellulose acetate in sheet form for the safety glass trade. G.R.S.

Assyrian text on glass manufacture. A. E. MARSHALL. *Jour. Chem. Ed.*, **10** [5], 267–69 (1933).—Studies of the many authentically dated specimens of ancient glass in museums and private collections have enabled investigators interested in the origin and progress of glass manufacture to reach some tentative conclusions on the succession of glass-forming processes. There is, however, a dearth of information on the chemical compositions of

ancient glassware or the raw materials used by early glassworkers. A careful translation of certain 7th Century B.C. Assyrian cuneiform tablets dealing with glass compounds and melting technique is reviewed and used as a basis of an estimate of the chemical knowledge of the Assyrian glassworkers. A.K.

Chemical and physical researches on beryllium glasses. CARL AUGUST BECKER. *Sprechsaal*, **67** [10], 137–39; [11], 152–55; [12], 169–70; [13], 185–87; [14], 203–204; [15], 216–18; [16], 233–34; [17], 250–51 (1934).—(1) A number of beryllium glasses in systematic series (addendum and permutation) and several comparison glasses containing CaO, MgO, and Al_2O_3 were melted in a platinum crucible. The melts contained small amounts of impurities of Al_2O_3, CaO, and Fe_2O_3. (2) All the melts were analyzed; the method of Parson and Barnes for separating beryllium, aluminum, and iron oxides in silicate glasses was found suitable. (3) The hydrolytic stability was determined on grits of definite size. The beryllium glasses showed a remarkably high stability, similar to that of alumina glasses. From investigation of glasses containing the oxides of beryllium, magnesium, calcium, and aluminum, it was found that the stability decreases in the following order: Al_2O_3, BeO, CaO, and MgO. (4) Density, hardness, index of refraction, permeability to ultra-violet rays, and thermal expansion were investigated. The density of all glasses was determined according to three methods. The density of beryllium glasses lies between the densities of the corresponding calcium and magnesium glasses. This fact is explained by the volume relation of molecules of the silicates or of the corresponding crystals. (5) The modified Martens method was used for determining the scratching hardness of all glasses. The known fact that BeO considerably increases hardness was confirmed. It decreases with the addition of equal molar numbers to the base glass in the successions, BeO, MgO, CaO. The values of hardness of the corresponding beryllium and alumina glasses are almost identical. (6) Addition of BeO, MgO, CaO, and Al_2O_3 to the base glass increases the index of refraction; the indices of refraction of glasses increase in the following succession with equal molecular addition: Al_2O_3, MgO, BeO, CaO. The replacement of Na_2O by BeO effects little change in the index of refraction. (7) The ultra-violet permeability of all glasses was determined exactly for wave-lengths of 320, 310, 300, 290, 280$\mu\mu$. Melts with BeO, similar to the ordinary type of soda-lime-silica glasses, can be produced which, in spite of a high iron content (0.03 to 0.05% Fe_2O_3), possess almost a similar permeability to that of commercial glasses with a high ultra-violet permeability. This result may be affected by several factors. (8) The expansion behavior of all glasses was studied from room temperature to the softening temperature. The addition of BeO to the base glass and the replacement of Na_2O by BeO (on the molecular basis) lower the coefficients of expansion; the values of the coefficients of expansion of BeO glasses in comparison with those of the corresponding glasses with MgO, CaO, and Al_2O_3 lie between those of Al_2O_3 and MgO. It was found that beryllium oxide considerably advances the so-called stress-release temperature much more than magnesium or calcium oxides. From the curves of the thermal expansion of beryllium glasses of the addenda and comparison series, it follows that these BeO glasses will show, on working, the character of the so-called short glasses and similar viscosity properties to those of calcium silicate melts below the upper stress-release temperature. M.V.K.

Chilled glass. L. VON REIS. *Rev. belge ind. verrières, céram., émail.*, **4** [9], 194–99 (1933); *Z. Ver. deut. Ing.*, No. 23 (1933).—A rapid cooling in the critical zone produces a glass with considerable internal stress. Such glass is distinguished from ordinary glass by its particular properties such as (*a*) great resistance to flexion, (*b*) resistance to deformation, (*c*) high resistance to temperature variations, (*d*) regularity in the distribution of internal stresses, (*e*) inalterability, and (*f*) suitability for use as safety glass. A method of manufacturing chilled glass and experiments with it are described. Illustrated. M.V.K.

Employing slag in the manufacture of glass bottles. C. WILKE. *Chim. & ind.*, **31** [4], 988 (1934).—Blast-furnace slag containing 0.8 Fe_2O_3, 0.2 MnO, 2.1 S, 32 SiO_2, 10.5 Al_2O_3, 47 CaO, and 7.2% MgO was used. The batch in which such slag is introduced becomes more fusible permitting the amount of sodium carbonate used to be diminished (23%). This improvement in fusibility is due to the great number of constituents present. The sulfur content, present chiefly in the form of calcium sulfide, is another advantage. Because of the coloring properties of this material, blast-furnace slag forms a strong colorant for the glass. An 0.008% content of Na_2S and CaS colors it a deep orange. Bottles produced from a batch containing 12.5% blast-furnace slag are not inferior to bottles manufactured in the usual way as to resistance and color. They are easily cooled and resist heating well. M.V.K.

Essentials of glass technology based on American practice. IX. S. R. SCHOLES. *Ceram. Ind.*, **22** [6], 305–12 (1934).—Various tank designs for economy or convenience are described, and special features of each are pointed out. The efficiency of tanks seldom exceeds 15% and this figure can be reached only by drawing the tanks to the limit of their capacity for producing clear glass. The firing of tanks, heating schedules, draft and pressure, the luminous flame, and improved designs of tanks are discussed. The melting process is taken up, beginning with hand-charging of tanks, use of batch feeders, and temperatures for glass-melting, and an explanation of the mechanism of melting is presented. Chemical agents used for promoting the plaining or fining of glass are enumerated, the properties of each being stressed. Illustrated. For Part VIII see *Ceram. Abs.*, **13** [7], 175 (1934). E.J.V.

Evolution of gas from solid glass on heating. N. A. ORLOVA AND S. V. PTITZUIN. *Jour. Tech. Phys.* [U.S.S.R.], **3**, 596–601 (1933).—Graphs show the rate of desorption from lead and dolomite glass used for lamp bulbs. (*C.A.*)

Example of unhomogeneous corrosion of refractory brick outside the glass melt. ANON. *Sprechsaal*, **67** [16], 235 (1934).—Illustrated. M.V.K.

First glass filling station. ANON. *Glass Ind.*, **15** [5], 91–92 (1934).—A description of the steel-glass type of construction used in a Shell Oil Co. station in New York is given. Glass tile are set in mastic between horizontal steel

ribs. Some possibilities of this type of construction are listed. Illustrated. E.J.V.

Glass as illuminating material. WEIGL. *Glashütte*, **64** [1], 9–10 (1934).—The chief illuminating glass is ground, etched, and opacified glass. Ground glasses are used because of their transmission properties, the degree of which averages 85%. The power of dispersion must be high. It depends little on the degree of etching, but with a deeper grinding there is a greater loss in absorption. Opacified glass behaves differently in its light properties. The dispersion occurs in the interior of the glass on the opacifying particles; the dispersion of light depends on the size and shape of the particles. Opacified glasses are classified into reflection and transmission glasses. The former have a degree of transmission below 35%, while their degree of reflection amounts to 50 or 75%. The degree of transmission can be raised by increasing the size of the opacifying particles and by a more uniform distribution. Such results are obtained with slowly cooled phosphate glasses. M.V.K.

Glass melts with sodium tungstate. MAX THOMAS-WELZOW. *Glashütte*, **64** [13], 211–14 (1934).—Experiments were made with lime-soda, lead, and boric acid glass melts with a varied addition of Na_2WO_4 and reducing agents. Tungsten forms three oxides: (1) the dioxide, brown, (2) the trioxide, yellow and most stable, and (3) a blue oxide accepted as W_2O_5. The results are as follows: (1) The statement of Jako (Keramische Materialkunde, *Ceram. Abs.*, **7** [12], 871 (1928)) that glasses may be colored blue by tungstate compounds was not substantiated. (2) The addition of Na_2WO_4 produces an alabaster opacification in lead glasses but not in those containing boric acid and lime-alkali. (3) Boric acid and lime-alkali glasses absorb considerable amounts of tungstate. When too much is added, tungstate is precipitated as such. (4) It is possible to melt glasses with a relatively high WO_3 content. The properties of such glasses must differ from those of ordinary glasses. Bibliography. M.V.K.

Glass painting and architecture. O. LINNEMANN. *Glastech. Ber.*, **12** [5], 149–56 (1934).—The following points are discussed: (1) light apertures as architectural motif, and their rôle in the development of architecture, (2) possibilities of closing these apertures because of the appearance of glass as a structural material, (3) small colored glass pieces as fillers in window grills, (4) advance of leaded glass and the origin of painted glass after the discovery of black solder, (5) painted glass displacing decorated walls, the walls shrinking more and more and remaining only for support and arches, (6) triumphal passage of glass painting from the first demand for light to the standstill brought on by the appearance of the baroque feeling for space, and (7) development in the last hundred years. G.R.S.

History of the chemical apparatus industry. F. KRAISSL, SR. *Jour. Chem. Ed.*, **10** [9], 519–23 (1933).—The development of the laboratory glassware industry in the U.S. is given. A.K.

History of the York school of glass painting. I. J. A. KNOWLES. *Jour. Brit. Soc. Master Glass Painters*, No. 4, p. 25 (1926). **II.** *Ibid.*, No. 5, p. 16 (1926). **III.** *Ibid.*, No. 6, p. 30 (1927). **VI–VII.** *Ibid.*, **2**, 136 (1927–28); **2**, 193 (1928–29); **3**, 31, 85 (1929–30). **VIII.** *Ibid.*, **3**, 123, 189 (1929–30). **IX.** *Ibid.*, **4**, 32, 81 (1931–32). **X.** *Ibid.*, **4**, 146, 189 (1931–32). **XI. Favorite subjects in York glass.** *Ibid.*, **5**, 37–48, 82–92 (1933–34). Illustrated. (*J.S.G.T.*)

Improved regenerator design. S. A. FORTER. *Glass Ind.*, **15** [5], 87–89 (1934).—An ideal checker chamber design and checker setting directs the gases or air uniformly over the whole checker setting. The change in specific heat of the waste gases and air and checker mass at different temperatures should be compensated for by changes in the mass weight per cubic foot of the checker mass. These differences, greatest where the temperature differential is greatest and lowest where it is low, should permit a constant flow of gas or air. A straight, nonconnecting flue was used to divert the waste gases and air through the checker mass in a definite path, utilizing all the checker mass. Surprisingly uniform temperatures were obtained from top to bottom and from side to side, indicating no channeling of the gases. Designs for various flue types are presented. Illustrated. E.J.V.

Interpretation of the action of mineralizers. W. EITEL AND W. WEYL. *Chem. Erde*, **8**, 445–61 (1933).—The action of small amounts of volatile components on the viscosity, crystallization power, and inner molecular equivalent of glasses is reviewed. A crystallization theory is advanced which takes into account the field action of ions and dipoles and according to which complexes or stable lattice configurations may form. Absorption spectrum measurements on a Na-silicate glass colored with NiO were made, and from these the effects on the inner equilibrium of chilling and of fluoride addition were studied. (*C.A.*)

Making a sheet of glass. R. M. WEEKS. *Proc. Roy. Inst.*, **28**, 97–114 (1934). (*B.C.A.*)

Mirror for world's largest telescope. ANON. *Bull. Amer. Ceram. Soc.*, **13** [6], 172–73 (1934); *Ind. Eng. Chem., News Ed.*, **12** [7], 122 (1934). PHILIP FOX. *Ceram. Ind.*, **22** [4], 187; [5], 256–59 (1934). GEORGE ELLERY HALE. *Glass Ind.*, **15** [4], 45–47 (1934). G. EDWARD PENDRAY. *Literary Digest*, **117** [14], 18 (1934). WALDEMAR KAEMPFERT. *N. Y. Times Mag.*, pp. 8–9 (April 1, 1934). GEORGE V. MCCAULEY. *Sci. Monthly*, **39** [1], 79–86 (1934); see also article by Day, *Ceram. Abs.*, **13** [6], 164 (1934).

New in lighting. ANON. *Arts & Dec.*, **41** [2], 10 (1934).—With an introduction on the requirements of modern lighting fixtures, this article concentrates on models of the Chase Brass and Copper Co. Illustrated. E.B.H.

New polariscope. FRANK W. PRESTON. *Glass Ind.*, **15** [5], 85–86 (1934).—A detailed description is given of a new polariscope intended for use on glass bottles and other complicated shapes, as well as on drawn sheet and rolled plate, especially if the latter is in the rough state so that detailed inspection is difficult. It is also of use, in connection with a furnace, for determining annealing "constants." It is usable as four types of polariscope without effort. Illustrated. E.J.V.

New standard brick allowing the construction of a wall of glass. ANON. *Céram., Verrerie, Email.*, **1** [8], 399–401 (1933).—A translucent brick of glass is made which can be used in regular masonry. M.H.B.

Old English glass. No. 52. FRANCIS BUCKLEY. *Glass*, **11** [5], 187–88 (1934).—A description of the work of the Birmingham Glass Pinchers is given. Illustrated. For No. 51 see *Ceram. Abs.*, **13** [7], 169 (1934). A.J.M.

Phase diagram of a glass for hollow glassware and some explanations of the reactions taking place in the formation of glass. M. HOLLENWEGER. *Z. tech. Physik*, **15** [4], 143–48 (1934).—The following glass composition was used: 78.39 SiO_2, 7.10 CaO, 13.91 Na_2O, and 0.60% Al_2O_3. The phase diagram is developed and the reactions while cooling down the liquid glass to room temperature are studied. Some properties of glasses are explained by taking into consideration thermodynamic laws. Glass containing silica is defined as a metastable solution of glass oxides in silica. W.M.C.

Present status of the technique of making safety glass on the basis of the published pertinent patents, with particular consideration of the German patents. W. RÖHM. *Kunststoffe*, **23**, 121–28, 158–63 (1933). (*C.A.*)

Principles of optical design in lighthouse practice. W. M. HAMPTON. *Glass Ind.*, **15** [5], 75–77 (1934).—The old lighthouses consisted of beacons without lenses and the use of the reflecting power of mirrors to increase the effect in the desired direction followed. In 1822 Augustine Fresnel invented the stepped lens. By the proper design and arrangement of lenses around a light source various types of lights are developed, various flashing combinations or fixed lights being obtained. The theory involved in the optical arrangements for each type is discussed. Illustrated. E.J.V.

Raw materials used in glass manufacture. ANON. *Glass*, **11** [5], 180–83 (1934).—A description and tests of silica and boric, phosphoric, and arsenious oxides are given. A.J.M.

Reciprocal action of arsenic and selenium in glass melts. ANON. *Keram. Rund.*, **42** [2], 17 (1934).—The assumption that a simultaneous use of arsenic and selenium in glass melts is injurious because arsenic vapors destroy the red coloring produced by selenium is false. Observations show that arsenic promotes or destroys the red coloring obtained with selenium only according to the mixing proportion used. White coloring occurs when the amount of arsenic used is in exact proportion to that of selenium; with too little arsenic, the red coloring becomes weaker, while a too large amount of arsenic intensifies the red coloring. In this case the glass has a dirty greenish tinge. A selenium arsenic decoloration has an advantage, however, as the color of the glass becomes more stable. This shows that additions of arsenic stabilize the color. M.V.K.

Regenerator reversal by time or temperature? ANON. *Glass Ind.*, **15** [5], 78–79 (1934).—Many glass plants reverse the air in the regenerator system on a time basis but often due to thermally unbalanced systems the degree of preheat from each generator will be different and at each reversal the furnace temperature will vary. Reversal on a temperature basis is accomplished by the use of pyrometric installations employing methods such as the temperature differential or the predetermined high temperature. The method of hooking up pyrometers in each regenerator or flue for temperature basis reversal is discussed in detail. The reversal by the temperature method has many advantages. Illustrated. E.J.V.

Safety glass systems. ANON. *Brit. Plastics*, **5** [60], 565 (1934).—A discussion is given of the utilization of alginates instead of the usual celluloid layer in the triple safety glass assembly. G.R.S.

Solutions of colloidal silica. ANON. *Ind. chimique*, **20** [237], 787 (1933).—Soluble silicates are decomposed by acids or mineral salts whose anions may yield little soluble salts with the cations of the silicic solution. Thus, when a soluble sodium glass is mixed with an equivalent amount of fluosilicic acid or a soluble potash glass is mixed with perchloric acid, sodium or potassium are precipitated in the form of fluosilicate or perchlorate. Very pure sols are destroyed by congelation, while a high electrolyte content prevents this congelation. M.V.K.

Two years of the Silesian College of Glass Technology in Bunzlau. K. LÜTZOW. *Sprechsaal*, **66** [34], 574–75 (1933).—A brief review is given of courses, studies, and practical work done by students. Illustrated. M.V.K.

Types of building glass. FRITZ HANSEN. *Diamant*, **56** [10], 110–12 (1934).—The types of glass used for building purposes are (1) *sheet glass:* window, cast, and plate glass; (2) *opaque:* alabaster, black, and colored opaque glass; (3) *pressed glass:* glass roof tile, brick, and flooring tile. Their manufacture and use are described. M.V.K.

Ultra-red measurements in glasses. K. KAISER. Presented at meeting of the Kaiser Wilhelm Institute for Silicate Studies, 1933; abstracted in *Sprechsaal*, **67** [5], 61 (1934); *Keram. Rund.*, **42** [6], 74 (1934).—In glasses and solutions containing the same coloring metal cations, the shapes and positions of the bands appearing in the visible and ultra-red parts of the spectrum nearly harmonize. This is easily explained by the fact that the change of the energy of electrons is decisive for the position of the whole band in the spectrum, while the small differences in the position and shape of the bands depend on deviations in the vibration and rotation energies. It follows that the possible vibration processes in glasses as in solutions have a comparable character throughout. The cation is affected by the different structure of anions. Suhrmann studied in solutions the dependence of ultra-red bands on the kind of cations and anions introduced. The additions of oxides or salts likewise change the spectral structure. The study of the specific vibration of anions is most important for the determination of the constitution of glasses. The energy of electrons is equal to zero here. The change of the energy of vibration and rotation produces a spectrum characteristic for every anion. The important ingredients of glass are the various degrees of oxidation of silicon. The knowledge of the specific vibration of Si_nO_m anions is necessary to define the constitution of glass. The X-ray study of the lattice structure of the crystalline Si_nO_m is of help. It shows that the ultra-red specific frequencies of the crystalline modification of Si_nO_m are still maintained in glass. M.V.K.

BOOK REVIEW

Physical Optics. ROBERT W. WOOD. 3rd ed. xvi + 846 pp., 462 figs. Macmillan Co., New York, 1934. Price $7.50. The outstanding quality of this book is its excellent presentation of experimental optics. It is

filled with practical suggestions for the aid of those who are curious about optical phenomena. Although the new edition contains only 132 pages more than the second, only 332 pages have been retained from the previous edition, the remaining 495 of text material being new. The chapter on dispersion has been almost completely rewritten and now contains the newer form of theoretical treatment from the classical viewpoint. This theory ties together scattering and dispersion along the lines laid down by Lord Rayleigh and further developed by Ewald and others. The underlying physical principles are presented with unusual clarity with the aid of graphs and descriptions of illustrative experiments. The chapter on the Raman effect presents an excellent summary of the subject. It contains a wealth of information as to the most efficient experimental procedure. Several fine illustrations of the effect are given. The application of the theory to experimental results is made clear by the specific detailed discussion of several cases. This is one of the most timely and interesting topics in the new edition. This third edition is an important contribution to the literature in the field of optics, particularly experimental optics. It is gratifying to note the extensiveness of the revisions which do justice to the immense progress in optics during the 22 years since the publication of the second edition. (*R.S.I.*)

PATENTS

Alternating-current furnace for the melting of glass, water-glass, cement, etc. Aktiebolaget Surte-Liljedahl (C. E. Cornelius, inventor). Swed. 78,914, Nov. 14, 1933. The fused material serves as electric resistance between electrodes having a large heat-accumulating capacity. Structural features are given. (*C.A.*)

Apparatus for annealing glassware. H. A. Wadman (Hartford-Empire Co.). U. S. 1,961,512, June 5, 1934.

Apparatus for feeding liquid glass mass to molding machines. Aktieselskapet Moss Glasvaerk. Norw. 53,-021, Sept. 4, 1933. (*C.A.*)

Apparatus for grinding reflectors. G. F. Tauchmann. U. S. 1,960,291, May 29, 1934.

Apparatus for heating glass tubes to form annular constrictions or swellings. Osram G.m.b.H. Komm.-Ges. (Hans Joachim Spanner and Werner Lukas, inventors). Ger. 585,899, Oct. 12, 1933. (*C.A.*)

Apparatus for making wired glass. Pilkington Brothers, Ltd. Ger. 590,134, Dec. 23, 1933. This corresponds to Brit. 381,228, *Ceram. Abs.*, **12** [1], 16 (1933). (*C.A.*)

Apparatus and method for making wire glass. E. W. Paxton and A. W. Schmid (Mississippi Glass Co.). U. S. 1,960,315, May 29, 1934.

Apparatus for polishing ground and smoothed surfaces of glass, and method of utilizing such apparatus. Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny, et Cirey. Brit. 409,943, May 16, 1934.

Cementing glass sheets. C. G. Boström and G. C. H. Ehrensvärd. Swed. 78,591, Oct. 10, 1933. The surfaces to be joined are matted and a layer of a suitable cement is applied which fills the depressions of the matted surface and thus restores the transparency. Finally the glass surfaces are pressed together. (*C.A.*)

Compound transparent or translucent materials. Soc. Anon. Vetreria Italiana Balzaretti Modigliani. Brit. 402,633, Dec. 13, 1933.

Container for melting glass. Firma Oscar Gossler (Gedeon v. Pazsiczky, inventor). Ger. 585,761, Oct. 10, 1933; addition to 580,502, *Ceram. Abs.*, **13** [7], 180 (1934). (*C.A.*)

Continuous apparatus for drawing glass tubes. Corning Glass Works. Ger. 576,341, May 13, 1933. This corresponds to Brit. 354,509, *Ceram. Abs.*, **10** [11], 775 (1931). Ger. 586,684, Oct. 24, 1933; addition to 576,341. (*C.A.*)

Cooling bridge walls for glassmelting furnaces. W. W. Oakley (Corning Glass Works). U. S. 1,960,164, May 22, 1934.

Coupler for glass supporting tables. J. C. Gipe (Libbey-Owens-Ford Glass Co.). U. S. 1,960,581, May 29, 1934.

Decorating glass. Soc. industrielle de façonnages sur Glaces. Fr. 756,045, Dec. 4, 1933. A layer of bakelite varnish is spread on silvered or painted glass and covered with a solution of ordinary bitumen not sensitized to light and then, after drying, with a layer of dichromated bitumen. The whole is exposed to light under a negative, the unexposed bitumen is afterward removed by washing with water, and the bitumen and bakelite are removed by appropriate solvents. The Ag thus exposed is converted to chlorite and removed, or the paint is removed by a solvent, leaving a design on the glass. (*C.A.*)

Device for drawing glass tubes. Glaswerke Ruhr A.-G. Ger. 585,689, Oct. 6, 1933. (*C.A.*)

Device for hardening glass plates by blowing air upon them while hot. Compagnies réunies des glaces et verres spéciaux du nord de la France. Ger. 585,535, Oct. 5, 1933. (*C.A.*)

Electric glassmelting furnace. Aktieselskapet Raeders Elektroglasovn. Norw. 53,287, Nov. 13, 1933. An electrode furnace is described in which the fusion proper serves as the electrical conductor. The raw material is charged in a heap between the electrodes; the distance between the active electrode surfaces is less on top of the charge than below, in order to concentrate the heat in the unmelted charge. Structural features are given. (*C.A.*)

Eyeglass construction. G. E. Nerney (Bay State Optical Co.). U. S. 1,960,791, May 29, 1934.

Forehearth for glassmelting furnace. Hartford-Empire Co. Ger. 589,093, Dec. 4, 1933; see Brit. 368,089, *Ceram. Abs.*, **11** [6], 364 (1932). (*C.A.*)

Furnace and regenerator construction therefor. C. F. Ryan (Hartford-Empire Co.). U. S. 1,961,510, June 5, 1934.

Gaging glass articles. D. E. Gray (Corning Glass Works). U. S. 1,960,151, May 22, 1934.

Glass. Compagnies réunies des glaces et verres spéciaux du nord de la France. Fr. 755,207, Nov. 21, 1933. The construction of flowing table and rollers is described. (*C.A.*)

Glass. Corning Glass Works. Ger. 588,643, Nov. 21, 1933. A heat-resisting glass is made from SiO_2, Al_2O_3, B_2O_3, and alkali, the starting materials being mixed in

proportions resulting in the presence of SiO_2 76 to 90, Al_2O_3 up to 5, and B_2O_3 and alkali 6 to 14% in the finished glass. The preferred glass contains SiO_2 about 80, Na_2O 4, B_2O_3 13, and Al_2O_3 2%. (*C.A.*)

Glass. I. G. Farbenind. A.-G. (Hans G. Grimm and Paul Huppert, inventors). Ger. 589,035, Dec. 1, 1933; addition to 580,295, *Ceram. Abs.*, **13** [5], 118 (1934). SiO_2 normally used in making glass is replaced wholly or in part by Al_2O_3 and P_2O_5 in the proportion of more than 1 mol. of Al_2O_3 per mol. of P_2O_5. The excess of Al_2O_3 may be up to 18% of the weight of the glass. The glass obtained has a lower coefficient of expansion and a higher softening temperature than that made by the process of Ger. 580,295. Examples are given. (*C.A.*)

Glass. Marianne Wellmann. Ger. 585,816, Oct. 11, 1933; addition to 537,633, *Ceram. Abs.*, **11** [7], 412 (1932). The method of 537,633 for making Be borate glasses transparent to ultra-violet rays is modified by using alkali carbonate in place of Li_2CO_3. Thus the glass contains 15 to 25 parts of boric acid, 1 to 2 parts of $BeCO_3$, and an amount of alkali carbonate equivalent to 3 to 6 parts of Li_2CO_3. The glass is also useful for lenses, prisms, and Hg-vapor lamps. (*C.A.*)

Glass composition. E. E. Fisher (National Pigments and Chemical Co.). U. S. 1,962,496, June 12, 1934. A sand-soda-lime glassforming batch contains barium oxide as an initial ingredient thereof.

Glass cutting machine. A. L. Shaw and E. J. Shaw. U. S. 1,961,082, May 29, 1934.

Glass disk records for sound reproduction. Soc. d'exploitation des verreries de Bagneaux et Appert frères réunies. Brit. 409,930, May 16, 1934.

Glass feeding apparatus. A. H. Stewart. U. S. 1,961,093, May 29, 1934.

Glass grinding machine. H. J. Hamann (Libbey-Owens-Ford Glass Co.). U. S. 1,961,487, June 5, 1934.

Glassmaking furnaces. Vetreria Meccanica Toscana. Fr. 755,229, Nov. 21, 1933. (*C.A.*)

Glass-pressing apparatus. Eduard Redlhammer & Söhne-Glasfabrik. Ger. 585,615, Oct. 5, 1933. (*C.A.*)

Glass and process of making. E. E. Fisher (National Pigments and Chemical Co.). U. S. 1,962,495, June 12, 1934. A sand-soda-lime glass batch comprises as initial ingredients a barium compound and a relatively small quantity of titanium oxide.

Glass supporting stand. H. F. Clark and L. J. Pierce (American Window Glass Co.). U. S. 1,960,805, May 29, 1934.

Glass treatment. H. R. Moulton (American Optical Co.). U. S. 1,960,121, May 22, 1934. The process of forming a strengthened glass having clear visual characteristics is described.

Glassware forming machine. J. R. Hoge (Owens-Illinois Glass Co.). U. S. 1,959,428, May 22, 1934.

Heat-absorbing glass. Edwin Berger (Jenaer Glaswerk Schott & Gen.). U. S. 1,961,603, June 5, 1934. A heat absorbing glass contains at least 0.2% of ferrous oxide (FeO), phosphoric acid (P_2O_5), and boric acid, the total of phosphoric acid and boric acid amounting to at least 25%.

Heat-absorbing windows. Walter Linke. U. S. 1,957,279, May 1, 1934. *Dedicated to the public.* Besides many other theoretical questions, the difference between the requirements of heat filters for the light of film projectors and for sunlight especially is discussed. For windows oxidized compounds are used as heat absorbers, selected for a high (not necessarily their highest) transmissivity in the yellow-green and a substantial absorption band in the near infra-red, not farther away than 0.0015 mm. wavelength. In glass copper oxide is most effective, with a true iron silicate next. For coatings copper and iron oleates and resinates are proposed. The following three kinds of iron-bearing glass are discerned. In a reduced glass the iron is thought to be present in the metallic state, because the chemical process is identical with that of iron making. In oxidized glasses and especially in the glass-painters' fluxes with low melting point, colloidal particles of Fe_2O_3 give rise to various brown colors according to their size or partial dissolution. The true iron silicate eventually used for the invention is green or yellow-green in a lime-soda glass and is obtained by high and prolonged heating under oxidizing conditions and eventually cleaning with arsenic thrown into the glass in lump form; the rising vapor of this, by its strongly electro-negative character, collects all colloidal particles and conveys them as a colloidal vapor into the chimney. The color of the glass may be changed to green or yellow-green by boron, lead, or high soda contents or, according to the claims, by chromium or vanadium oxides. Walter Linke

Insulator and method of treating. G. S. Fulcher (Corning Glass Works). U. S. 1,960,147, May 22, 1934.

Laminated glass and process of producing. G. B. Watkins (Libbey-Owens-Ford Glass Co.). U. S. 1,960,520, May 29, 1934.

Lead silicates. Th. Goldschmidt A.-G. Ger. 590,119, Dec. 23, 1933. Lead silicates and lead alkali silicates for use in the manufacture of glass or glazes are manufactured in a hearth furnace from which gases are withdrawn by a mechanical suction device, whereby reduction to Pb is avoided. Preferably, the fuel and/or the air for combustion are supplied under pressure and are thoroughly mixed. (*C.A.*)

Lens. H. P. Gage (Corning Glass Works). U. S. 1,960,148, May 22, 1934.

Lighting fixture. L. C. Doane (Miller Co.). U. S. 1,959,819, May 22, 1934.

Machine for forming glass articles. A. S. Jackson and C. W. Hale (Owens-Illinois Glass Co.). U. S. 1,959,430, May 22, 1934.

Machine for the manufacture of ampullas, etc. Jakob Dichter. U. S. 1,962,985, June 12, 1934.

Manufacture of glass permeable to ultra-violet rays. W. W. Groves (I. G. Farbenind. A.-G.). Brit. 410,291, May 24, 1934.

Manufacture of tempered glass. Bernard Long (Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny et Cirey). U. S. 1,960,222, May 22, 1934.

Means for circulating molten glass. Floyd Flexon (Owens-Illinois Glass Co.). U. S. 1,959,417, May 22, 1934.

Means for obstructing the flow of molten glass. Louis Boudin (Soc. anon. des manufactures des glaces et produits chimiques de St. Gobain, Chauny et Cirey). U. S. 1,960,136, May 22, 1934.

Means for preventing formation of bubbles in molten glass. LEOPOLDO SANCHEZ VELLO. Ger. 584,163, Sept. 15, 1933; see "Preventing, etc.," this page. (*C.A.*)

Method and apparatus for conveying sheets of glass to the annealing leers in the discontinuous rolling process of manufacture. FORGES ET ATELIERS DE CONSTRUCTIONS ÉLECTRIQUES DE JEUMONT. Brit. 410,547, May 30, 1934.

Method and apparatus for feeding glass. E. C. STEWART. U. S. 1,961,015, May 29, 1934.

Method and apparatus for severing wire glass. E. W. PAXTON (Mississippi Glass Co.). U. S. 1,959,545, May 22, 1934.

Method of making articles of glassware. R. C. COBEL (A. H. Heisey & Co.). U. S. 1,960,729, May 29, 1934.

Method of making molded articles from white glass cased with colored glass. SÄCHSISCHE GLASFABRIK AUGUST WALTHER & SÖHNE A.-G. Ger. 589,094, Dec. 2, 1933. Manipulative features are described. (*C.A.*)

Pneumatic glass feeder. H. S. BRADY, I. H. FREESE, AND H. R. ECCLESTON (Hazel-Atlas Glass Co.). U. S. 1,959,811, May 22, 1934.

Pneumatic glass feeder. I. H. FREESE (Hazel-Atlas Glass Co.). U. S. 1,959,821, May 22, 1934.

Pneumatic glass feeder. DAVID STENHOUSE (Hazel-Atlas Glass Co.). U. S. 1,959,506, May 22, 1934.

Preventing the formation of bubbles or striae in molten glass in contact with a metal wall. LEOPOLDO S. VELLO. Brit. 379,216, Jan. 26, 1931. A subatmospheric pressure is applied to that surface of the wall not in contact with the glass. Apparatus for drawing glass tubes is described. (*C.A.*)

Process and apparatus for producing laminated glass. FRANK FRASER (Libbey-Owens-Ford Glass Co.). U. S. 1,960,580, May 29, 1934.

Process and means for manufacturing glass vessels from tubing. JAKOB DICHTER. Brit. 409,283, May 9, 1934.

Producing silver mirrors on glass. FIRMA MAX ERMES. Ger. 587,353, Jan. 5, 1934. Weather-resistant products are made by coating the Ag mirror with an alloy of Ag and a base metal. The alloy may be deposited on the mirror by reducing in the cold a solution containing Ag, Cu, Cr, Ni, and preferably Zn. Ger. 590,169, Dec. 27, 1933. The known processes, in which a solution of Ag salt is treated with a reducing agent in the cold, are improved by addition of a small proportion of cyanides to the Ag salt solution. A mixture of $Hg(CN)_2$ and KCN is preferred. See also Fr. 730,651, *Ceram. Abs.*, **12** [4], 152 (1933). (*C.A.*)

Safety glass. DUPLATE CORP. Fr. 755,652, Nov. 28, 1933. A means is described for applying a luting agent to the edges. (*C.A.*)

Severing mechanism for glass feeders. G. R. HAUB (Shawkee Mfg. Co.). U. S. 1,959,672, May 22, 1934.

Sheet glass apparatus. F. R. HOHMANN (Libbey-Owens-Ford Glass Co.). U. S. 1,961,494, June 5, 1934.

Surfacing machine. J. C. GIPE, J. P. CROWLEY, AND J. L. DRAKE (Libbey-Owens-Ford Glass Co.). U. S. 1,961,441, June 5, 1934.

Structural Clay Products

Brick dominates housing group at a Century of Progress. ANON. *Brick Clay Rec.*, **84** [5], 164 (1934).—Four brick houses will be seen at the 1934 Fair. The newer houses are of more conventional design. One steel-brick house to cost $3200 is being presented. Illustrated. E.J.V.

Brick and tile manufacture by the dry-pressing method. HERMANN KRUG. *Ziegelwelt*, **65** [1], 5–6; [2], 13–14; [3], 26–27 (1934).—Advantages and disadvantages of the dry-pressing instead of the wet-pressing method are discussed. M.V.K.

Change in size of brick unit considered. ANON. *Brick Clay Rec.*, **84** [5], 168 (1934).—At a meeting of Hudson River brickmakers with architects and builders it was learned that a larger brick unit is desired, but definite action is being withheld for the present. E.J.V.

Early brickwork in New England. FRANK CHOUTEAU BROWN. *Pencil Points*, **15** [4], 165–80 (1934).—This is a history and description of early brick houses in New England. Photographs and measured drawings are given. E.B.H.

Manufacture and use of hollow and light brick. R. HORN. *Tonind.-Ztg.*, **58** [27–28], 340–41; [29], 356–57 (1934).—A general discussion is given. M.V.K.

New brick wall provides air conditioning. WESTERN BRICK & SUPPLY CO. *Brick Clay Rec.*, **84** [6], 197 (1934).—The Farrenwall System of brick-wall construction gives a hollow wall having a 4-in. air space in the center. The brick used are larger than standard size and there are no continuous mortar joints through the wall, yet it is thoroughly bonded together with brick giving it lateral strength. It is claimed to be a thoroughly dry wall. Illustrated. E.J.V.

Paving brick at Chicago Fair. ANON. *Brick Clay Rec.*, **84** [6], 195–96 (1934).—In Ford's display of "The Roads of the World" 375 sq. yd. of paving brick have been laid as an example of modern highway construction. Illustrated. E.J.V.

Reinforced face brick slabs for model farm house. ANON. *Brick Clay Rec.*, **84** [5], 160–63 (1934).—In this fabricated house of panel construction face brick slabs constructed of reinforced brick masonry on the building site and raised into place to form a monolithic load-bearing wall are used. The walls of the house are only 4 in. thick, the width of one brick, laid in basket weave. Some of the partitions are only 2 in. in width with brick set on edge. All of the walls are reinforced with $\frac{1}{4}$-in. steel rods. Illustrated. E.J.V.

Relative importance of properties of brick mortar. W. R. MCCAFFERY. *Canadian Eng.*, **66** [24], 12 (1934).—Brick mortar should be suitable for the specific type of brick being laid. The characteristics of mortars according to degree of importance are (1) plasticity (workability), (2) adhesion, (3) volume change, (4) elasticity, (5) absorption, (6) strength, (7) rate of hardening, and (8) staining and color retention. Water-retaining capacity is also of primary importance. E.J.V.

Sand-lime brick. ANON. *Chem. Trade Jour.*, **94** [2447], 268 (1934).—One of the outstanding advantages

that sand-lime brick possess is their light color and good reflecting properties. They may be colored by the addition of a pigment; a red oxide pigment gives various shades of red or brown, while carbon black gives gray shades. Sand-lime brick may be painted if free lime and alkali salts are not present together either in the brick or the mortar. They do not tend to form efflorescences on their surfaces and are a cheap and satisfactory substitute for glazed brick for the interior of buildings.

M.V.K.

Solving production problems in a sewer-pipe plant. ANON. *Brick Clay Rec.*, **84** [6], 198–99 (1934).—When certain pipe would not take salt glaze, a study was made of samples of all the types of clay from the pit, resulting in locating scumming and high lime content in the top 2-ft. layer as the cause of the trouble. By discarding this as waste the trouble was overcome. By improving the tempering of the clay slabs, scaling off during water-smoking was stopped. Pipe checking on drying on the floor was caused by crooked pallets. Tests on fast drying of pipe are described. E.J.V.

Study of the properties of mortars and brick and their relation to bond. L. A. PALMER AND D. A. PARSONS. *Bur. Stand. Jour. Research*, **12** [5], 609–44 (1934); R.P. 683.—The water-retaining capacity, transverse strengths, sorption, volume changes, and moduli of elasticity of 50 mortars and the absorption rate, moisture expansion, and transverse and compressive strengths of 6 makes of brick were studied. Fifteen of the 50 mortars were used with the 6 makes of brick in tests of brick-mortar assemblages. The following conclusions are applicable only to the conditions, materials, proportions, and types of specimens discussed: (1) The extent of bond is affected by the properties of both mortars and brick but chiefly by the water-retaining capacities of the mortars and the absorption rates of the brick. (2) With brick of high rates of absorption set dry, the extent and, in most cases, the strength of bond were best with mortars of high water-retaining capacity. (3) Although the extent of bond was good, the strength of bond obtained with very impervious brick having smooth, glassy, bonding surfaces was generally lower than that obtained with the other makes of brick. (4) Rough-surfaced brick with low rates of absorption and mechanically smooth and porous brick made practically nonabsorptive by soaking in water gave good extent of bond when time was not permitted in brick laying for the water in mortars of low water-retaining capacity to separate out. When such time was allowed, the extent of bond was poor with the mortars of low water-retaining capacity. (5) The maximum bond strength at 3 months was obtained in the case of all mortars with brick having a rate of absorption of approximately 20 g. of water per 30 sq. in. of brick surface per min. when partially immersed (flat side down) to a depth of $^1/_8$ in. in water. This does not imply that the maximum extent of bond was obtained with this rate of absorption. (6) When the extent of bond is practically complete, the results do not indicate an appreciable weakening of the bond through shrinkage of the mortar during early hardening. (7) There is no evidence that volume changes in mortar subsequent to hardening destroyed or weakened the bond either in vertical or horizontal joints, when the extent of the bond is good. When the extent of bond is poor, there is some indication that volume changes subsequent to hardening were destructive to the bond. (8) The bond with mortars of low sorption and high strength was most resistant to alternate freezing and thawing. In the study of bond durability only impervious brick and brick made nonabsorptive by wetting were used. (9) From the standpoint of bond durability and considering all the mortars included in this study, it is indicated that best results may be generally obtained by keeping the rate of absorption of brick below 40 g. of water, as obtained by partial immersion (flatside down) for 1 min. in water. (10) The maximum bond strength at 3 months with the 15 mortars increased with the compressive strength of the mortars as determined at 3 months, the conditions of curing the brick mortar specimens and the mortar cubes being the same, provided that the extent of bond was good. (11) With brick of low rates of absorption and porous brick made practically nonabsorptive by wetting, the highest bond strength was obtained with mortars of highest strength, when the extent of bond was good. (12) The data indicate that mortars of widely different compositions may have similar properties. (13) The data further indicate that a poor extent of bond may be obtained with certain combinations of brick and mortars simply because the 2 materials are not well suited to one another and not because of any defect that would be apparent from tests according to present-day specifications.

R.A.H.

Supplying the architect with special shapes profits the manufacturer. L. R. WHITAKER. *Brick Clay Rec.*, **84** [6], 203–204 (1934).—W. urges that the architect be given special shapes and types of brick. The making of extra size shapes is not as difficult as imagined and is well worth the trouble. Illustrated. E.J.V.

Supplying specialty units builds good business. BEL-AIR BRICK CO. *Brick Clay Rec.*, **84** [5], 163 (1934).—By developing its own line of special products the Bel-Air Brick Co. of Santa Monica, Calif., has built up a profitable business. Among the specialties are a large hand-made fired adobe brick 4 in. thick made in three sizes up to 12 x 17 in., a 2-in. thick common hand-made floor tile made in 4 x 16, 8 x 16, and 8 x 8 in. sizes, and a special patio wall brick 4 x 6 x 16 in. E.J.V.

Water-tightness of masonry walls depends on mortar properties. L. A. PALMER. *Brick Clay Rec.*, **84** [6], 208–10 (1934). E.J.V.

World's Fair brick houses impress visitors. ANON. *Brick Clay Rec.*, **84** [6], 200–201 (1934).—The group of brick houses at the Century of Progress exhibits strength of reinforced brick masonry, face-brick slab construction, economy of steel framing and brick, and a new kind of brick. Illustrated. E.J.V.

PATENTS

Brick. ALBERT CRUM. U. S. 1,959,816, May 22, 1934. A hollow brick has closed ends and sides.

Brick-lug forming mechanism. F. B. DUNN. U. S. 1,960,101, May 22, 1934.

Cellular ceramic process and apparatus. E. R. POWELL. U. S. 1,963,031, June 12, 1934.

Ceramic slab-forming process and apparatus. E. R. POWELL. U. S. 1,963,029, June 12, 1934.

Combination cesspool, rain conductor, and catch basin. DANIEL COHEN. U. S. 1,960,806, May 29, 1934.

Conduit joint. J. M. HARDESTY (Bell Telephone Laboratories, Inc.). U. S. 1,959,421, May 22, 1934.

Expansively fired ceramic material. F. W. BUTTERWORTH, I. N. DOUGHTY, AND I. R. CLINE (Western Brick Co.). U. S. 1,960,573, May 29, 1934.

Method and apparatus for firing argillaceous material. F. W. BUTTERWORTH AND I. R. CLINE (Western Brick Co.). U. S. 1,960,572, May 29, 1934.

Method of forming cellular ceramic building material. E. R. POWELL. U. S. 1,963,030, June 12, 1934.

Method or process for the expansive firing of clays. F. W. BUTTERWORTH, I. N. DOUGHTY, AND I. R. CLINE (Western Brick Co.). U. S. 1,960,571, May 29, 1934.

Porous materials from clay. E. I. LINDMAN. Swed. 78,881, Nov. 7, 1933. Highly porous materials are produced by firing clay, argillaceous materials, or rocks in a tunnel furnace with moving bottom at such high temperatures that expansion takes place as a result of gas development in the interior of the materials. The raw material is charged in a thin layer on the moving furnace bottom formed by a close succession of cars and heated from above. (*C.A.*)

Process for manufacture of brick, tile, pipe, etc. S. HOWARD. Brit. 410,611, May 30, 1934.

Refractories

Alumina from Poshan bauxite. EARL O. WILSON AND YU-LING KAO. *Jour. Chinese Chem. Soc.*, **1**, 120–38 (1933).—The finely ground ore, after being calcined with soda ash and lime for 4 hr. at 1050°, is extracted with hot H_2O, and the SiO_2 is removed by boiling with CaO; the Al_2O_3 is precipitated with CO_2. The product is satisfactory for metallurgical purposes and contains 98.81% Al_2O_3 and 0.21% SiO_2. (*C.A.*)

Characteristic diagram of a crucible designed for heating by high-frequency induction. ANON. *Jour. four élec.*, **43** [3], 97–99 (1934).—Principles upon which the basis of the diagram is established are outlined. An example is given of the use of the mathematical formulas. G.R.S.

Checker construction in the blast-furnace hot stove. ANON. *Iron Age*, **133** [18], 22–24 (1934).—A new type of hollow fireclay tile with graduated inserts is used (Brassert tile) in the blast-furnace hot stove. Data on a stove with the new Brassert tile as compared to a stove equipped with straight checkerwork are given as follows:

	Brassert tile	Straight tile
Sq. ft. of heating surface/cu. ft. of checkers	9.057	5.553
Free area/sq. ft. of checker area	0.34	0.405
Brick vol. in cu. ft./sq. ft. of heating surface	0.0728	0.1071
Brick vol. in cu. ft./cu. ft. of checker work	0.66	0.595
Heat transfer coefficient in B.t.u./hr./sq. ft. of heating surface/1°F	5.57	3.12

A.K.

Chemical investigation of refractories. IV. Examination of refractory tile and refractory coatings containing zirconium. H. J. v. ROYEN AND H. GREWE. *Arch. Eisenhüttenwesen*, **7**, 505–12 (1934).—After silica is removed, zirconium may be separated from the other elements only in a highly acid solution, such as 10% sulfuric acid, phosphate being used as a precipitant. The precipitate is decomposed into sodium zirconate, dissolved in hydrochloric acid, and precipitated as zirconium dioxide using ammonia or "Kupferron." Pure zirconium phosphate will be obtained when no elements forming insoluble phosphates are present. General rules are presented for chemical analyses including the examination of refractories of high alumina content. **V. Examination of refractories made of silicon carbide and carbon.** *Ibid.*, **7**, 513–16 (1934).—A method of investigation for refractories containing silicon carbide, graphite, and carbon is presented. No special difficulties were encountered in analyzing carbon-containing bodies. **VI. Determination of alumina in clays and refractories.** *Ibid.*, **7**, 517–21 (1934).—A new, fast-working method by W. Mattheis, allowing the determination of alumina and titanium dioxide in clays and refractories, was tested. The method is based on the precipitation of aluminum as a phosphate. The wearisome elimination of silica by means of evaporation is not necessary. Results will be obtained in 7 hr., the accuracy being almost the same as that obtained by the standard method of analysis. Temperature and time were determined for calcining aluminum hydrate and aluminum phosphate. For Part III see *Ceram. Abs.*, **10** [5], 356 (1931). W.M.C.

Cupola refractories. EDWARD E. MARBAKER. *Trans. Amer. Foundrymen's Assn.*, **5** [2], 491–96 (1934).—The paper discusses (1) requirements of cupola refractories, (2) tap-out and slag-hole block, (3) daubing or relining, and (4) cupola operation and refractory service. The lining of the cupola above the melting zone is not subjected to very high temperatures or to slag action, if the limestone flux is added properly. In the melting zone the lining is subjected to the hardest possible service: high temperature, slag penetration, abrasion, and spalling. The melting zone should be lined with a high-quality clay refractory. M.V.K.

Development of electric steel furnace construction after the War. MAASE. *Feuerungstechnik*, **22** [4], 50 (1934).—A brief review is given. Illustrated. M.V.K.

Electric conductivity of refractory oxides. E. ROUSSEAU. Thesis presented to the Faculty of Sciences of Lille; abstracted in *Ind. chimique*, **21** [243], 267 (1934).—Refractory oxides, particularly magnesia and alumina, are used extensively in the thermal insulation of electric furnaces; magnesia is also used for the production of conducting linings for the foundation of *Héroult* furnaces. The law of variation of the electric conductivity as a function of temperature was verified. Between 1400° and 1720°, the resistivity of a magnesia crystal follows the law of Joffé, $\log r = A + B/T$. Fused magnesia conglomerates follow the law up to 1550° only; above it,

the resistivity decreases rapidly because of the formation of "arches" between the grains. Magnesia crystals have a better conductivity than magnesia conglomerates. The effect of different factors on the electrical conductivity of magnesia conglomerates was also studied. The results show that (1) the resistivity decreases with the increase of the grain size; (2) the resistivity decreases slightly when the conglomerate is submitted to a strong current under high tension; (3) the addition of oxides, such as Na_2O, K_2O, LiO_2, La_2O_3, Nd_2O_3, Pr_2O_3, GlO, ZrO_2, and SiO_2, aids the resistivity of magnesia. CaO and GlO, which may be present in magnesia in solid solution, have the best effect. The system MgO–Al_2O_3 was also studied; the resistivities of Al_2O_3 and MgO are 135,000 and 12,350 ohms/sq. cm., respectively. A mixture containing 2% MgO conducts 7 times better than pure alumina; the spinel $MgO{\cdot}Al_2O_3$ has a resistivity similar to that of pure magnesia, 16,000 ohms/sq. cm. at 1500°. The apparent porosity of the samples seems to indicate that there is a relationship with the alumina content. The maximum of porosity was found in spinel; this property can be used to study the existence of combinations in other systems. Tests with silicon carbide show that this material has a much better conductivity than alumina or magnesia. When cold its resistivity amounts to only 28.4 ohms/sq. cm. The law of Joffé is less applicable in its case than for the oxides MgO and Al_2O_3. Its resistivity varies less rapidly with the temperature. The precise measurement at high temperatures was studied also. M.V.K.

Factors affecting the service of clay refractories in iron foundries. R. C. Zehm. *Trans. Amer. Foundrymen's Assn.*, **5** [2], 497–501 (1934).—Refractories of the type used in iron foundries are generally made from a raw material and grog. The properties of fire clay for manufacturing refractories, the importance of grain size, methods of manufacturing, and selection of refractories are discussed. M.V.K.

Further investigations of basic refractories for steel-melting furnaces. A. H. B. Cross and W. J. Rees. Presented at meeting of English Ceramic Society at Llandudno, May, 1934; abstracted in *Colliery Guard.* **148** [3830], 990 (1934). E.J.V.

International Congress on Glass and Ceramics. Anon. *Ind. Eng. Chem., News Ed.*, **11** [22], 329 (1933).—At the meeting held in Milan, Italy, the following problems were discussed: (1) to select a method for increasing the plasticity of clays and argillaceous earths to prevent dropping during the preparation of ceramic pastes; (2) to choose a reagent which will accelerate the change of crystalline quartz into tridymite at not too high temperatures, so as to reduce the nonuniform contraction during heating to a minimum; (3) to consider the refractivity and high thermal activity of silicon carbide, to find a coating to protect it from the corrosive action of alkaline vapors, so that it might be used in place of the other more common refractories; and (4) to develop something which will eliminate the frequent changes now necessary in the fabrics used in retaining ceramic pastes on pressure filters. Bearing in mind the utility of the new gas-heated furnaces for firing ceramics, it is nevertheless considered that changes of equipment at this time would be inadvisable, because of the poor economic conditions. The recent adoption of tunnel kilns, in place of the intermittent kilns previously in use, assures a satisfactory reduction in fuel consumption, so that further improvement may be postponed to more prosperous times. Radiation losses from noninsulated furnaces are found to be 50% of the total fuel consumption, so it is advisable to insulate, using fire brick cemented together by suitable binders. See also *Ceram. Abs.*, **13** [7], 196 (1934). F.G.H.

Method of measuring thermal conductivity at furnace temperatures. Clarence E. Weinland. *Jour. Amer. Ceram. Soc.*, **17** [7], 194–202 (1934).

Modern methods of heat insulation. Cyril S. Woodward. *Trans. Ceram. Soc.* [Eng.], **33** [2], 73–84 (1934).—W. lists and discusses the types of heat insulation in use throughout various temperature ranges, 50 to 212°F, 212 to 600°F, 600 to 1000°F, 1000°F and over, and considers briefly the theory of heat losses. R.H.H.P., Jr.

News and actualities in the manufacturing methods of refractory products. J. A. *Rev. mat. constr. trav. pub.*, No. 294, pp. 55–56*B* (1934).—Slate clay is used for the production of refractory grog. The material is roasted to 400 or 600°C, the iron impurities removed by electromagnetism, and the material is further calcined. The products obtained have a good resistance to load and to spalling tendencies. "Sinton" is a clay fired to the softening temperature at which it obtains a maximum content of mullite and constant volume. The mullitization of refractory clays consists in mixing an appropriate volatile hydrocarbide with the clay and heating the mixture in a vacuum between 700 and 1600°. The refractories obtained show a good resistance to slag. Presses working under great pressure have been developed; tank blocks pressed in a vacuum are extremely dense. Production by casting and compression permits the use of less raw bonding clay. This clay is made colloidal by adding electrolytes (sodium silicate and carbonate) and mixing with 99 to 95% grog. Spinel refractories are being used more extensively in Germany, Russia, and U.S.A. (black Dinas, brown tridymite brick for Martin furnaces, and sillimanite and mullite refractories). Mullite is obtained by firing sillimanite minerals (cyanite, dumortierite, sillimanite, disthene) to 1300 to 1500° according to the reaction $3(Al_2O_3, SiO_2) = 3Al_2O_32SiO_2 + SiO_2$, corresponding to 78.6% mullite and 12.4% cristobalite. Mullite is crushed after calcining and sifted. Some bonding clay is added and the pieces are fired between 1400 and 1700°. Fused mullite (Corhart) is fused in electric furnaces; the products are homogeneous, have a high conductivity, and are gas-tight. Fused magnesia and chrome-magnesia refractories have been produced in the same manner. These products are no longer fragile and sensitive to temperature changes. Siemensite, obtained as a by-product in the production of ferro-chrome in arc furnaces, corresponds to the following variable composition: 20 to 40% Cr_2O_3, 25 to 45% Al_2O_3, 18 to 30% MgO in the form of spinel, and from 8 to 14% of other components, usually silicates. Siemensite presents remarkable properties, being unaffected by most chemicals. Its disadvantage is a great dilatation with increasing temperature. M.V.K.

Permeability of refractory materials to gases. III. F. H. Clews and A. T. Green. *Bull. Brit. Refrac.*

Research Assn., No. 28 (Aug., 1932); reprinted in *Trans. Ceram. Soc.* [Eng.], **33** [1], 21–32 (1934).—The permeability to nitrogen of thirteen representative refractory products has been measured at temperatures between 500 and 850°C with the apparatus previously described modified for use at higher temperatures. The permeability is reduced to 0.5 its value for a temperature increase from 10 to 500°C and to 0.4 its value for a temperature rise from 10 to 850°C apparently independent of the nature of the material and the value of its permeability coefficient at room temperature. For silica refractories the values are slightly less. The decrease is shown to be due almost quantitatively to the rise in the viscosity of the gas with increasing temperature. See *Ceram. Abs.*, **13** [3], 63 (1934). R.H.H.P., Jr.

Questions of molding when manufacturing refractory brick. Hans Kremski. *Tonind.-Ztg.*, **58** [29], 353–55 (1934).—The molding and pressing of refractory brick for cupola furnaces are discussed. See also *Ceram. Abs.*, **13** [5], 123 (1934). M.V.K.

Refractory materials. Twenty-Fourth Report of Joint Sub-Committee. *Gas Jour.*, **204** [3676], Supp., pp. 9–12 (1933).—Abstracts are given of the following reports of work carried out by the British Refractories Research Association: (1) "Hot-patching of gas retorts—use of dry powdered cements containing silicon and aluminium," by F. H. Clews, H. Booth, and A. T. Green; (2) "Grading, porosity, and permeability to air of silica brick," by F. H. Clews and A. T. Green; (3) "Action of alkalis on refractory materials," by F. H. Clews, A. Green, and A. T. Green; (4) "Flaking of continuous vertical retorts," by A. T. Green and F. H. Clews. G.R.S.

Refractory materials for boiler fire boxes. F. Fromm. *Glückauf*, **69** [32], 722–28 (1934).—Most refractories used in practice belong to the system silica–alumina. The melting-point diagram of the system is discussed. The range from 95 to 98% SiO_2 comprises the silica brick, 12 to 30% Al_2O_3 is the quartz-fireclay brick, and up to 46% Al_2O_3 the fire brick. Higher alumina content is obtained by using alumina hydrates or synthetic fused corundum; the only stable compound in this range at higher temperatures is mullite, $3Al_2O_3 \cdot 2SiO_2$, with about 72% alumina. Fused materials have been used recently to a great extent; they are very dense and therefore resistant to slag attack, but rather expensive and not resistant to temperature changes. Silicon carbide brick are used in the firing zone because of their high mechanical strength. Zirconium brick have been used only experimentally. Chromite and magnesite are not sufficiently resistant to temperature changes. For boiler fire boxes usually quartz fire brick and fire brick of the composition $2H_2O \cdot Al_2O_3 \cdot 2SiO_2$ are used. Manufacture and binders for building are briefly described. The principal causes of destruction are temperature changes and slag attack, the latter leading often to spalling. Mechanical attack is due to impinging of fly-coke and fly-ash particles. Testing methods are described and the construction of ordinary and expansion joints, suspended roofs, and arches is discussed. As a protective means to lengthen the life of brickwork of the fire boxes F. suggests (1) use of suitable materials, (2) enlarged combustion chamber, (3) air-cooling of walls and roof, (4) installation of cooling pipes (radiation boilers, Bailey chamber), and (5) change of fuel. A number of operating experiences illustrate the several points. M.H.

Selection and nature of refractory materials for the ceramic industry. F. Niebling. *Keram. Rund.*, **42** [5], 55–58 (1934).—The chief refractories used in the ceramic industry are as follows: (1) Pure basic grog brick containing up to 32% alumina and having a cone of 30 to 34 or 35 with an alumina content over 42%. (2) Semiacid quartz-containing refractories with a P.C.E. of 29 to 32 or 33 and manufactured from refractory clay and granulated quartz or luting sand. They are used in firing channels of zigzag and circular kilns; they have a lower mechanical strength than grog brick, and are attacked by slag and flue ashes. (3) Acid quartz-lime or silica brick (almost pure quartz) having a P.C.E. of 35 to 36. They have a high strength and resist very high temperatures in a dry flame free from ash and slag. Silica brick are used in crowns of firing chambers with gas firing. They are destroyed by ash and flue ashes. (4) Highly basic bauxite brick with a P.C.E. of 36, high alumina content, density, and mechanical strength are used in the sintering zone of cement shaft and revolving furnaces. (5) Silicon carbide brick are very hard and have a high thermal conductivity and valuable physical properties; their P.C.E. is from 38 to 40. It is a good material for muffles and firing plates. The use of these refractories in different parts of furnaces is discussed. The size of refractories is important; the life of a refractory decreases with increased size. The composition of the mortar used must correspond to that of the brick. M.V.K.

Significance of permeability to gases in relation to the texture and industrial usage of refractory materials. F. H. Clews and A. T. Green. *Bull. Brit. Refrac. Research Assn.*, No. 27 (March, 1932); reprinted in *Trans. Ceram. Soc.* [Eng.], **33** [2], 56–72 (1934).—The importance of porosity and permeability data in a study of the structure and texture of refractory products is discussed, especially in regard to permeability to gases and the mechanism of corrosion in industrial installations such as gas retorts, blast furnaces, boiler settings, glass tanks, and recuperators. See also *Ceram. Abs.*, **12** [3], 111 (1933). R.H.H.P., Jr.

Silica and its fundamental properties in different types of refractories. E. V. *Rev. mat. constr. trav. pub.*, No. 294, pp. 50–53*B* (1934); translation of paper by C. N. Witherow, *Ceram. Abs.*, **12** [9], 331 (1933). M.V.K.

Special refractories for metallurgical research at high temperatures. Donald Turner. *Trans. Ceram. Soc.* [Eng.], **33** [2], 33–55 (1934).—A series of special refractories of a high degree of purity and possessing good mechanical strength, great resistance to heat, and in some cases imperviousness to gases has been developed to satisfy the requirements of a series of researches on alloys of iron. The technique used in the manufacture of pure alumina crucibles and tubing is described in detail. R.H.H.P., Jr.

Studies of refractory materials. No. 19. Olivine. Anon. *Refrac. Jour.*, **10** [5], 212 (1934).—The occurrence,

properties, and uses of olivine are described. For No. 18 see *Ceram. Abs.*, **13** [7], 184 (1934). A.J.M.

Study of the effect of natural gas and of hydrogen upon various refractories. BERTRAM C. RUPRECHT, R. H. H. PIERCE, AND FRED A. HARVEY. *Jour. Amer. Ceram. Soc.*, **17** [7], 185–93 (1934).

Superex insulation block. JOHNS-MANVILLE. *Blast Fur. Steel Plant*, **22** [5], 294 (1934).—By use of a special calcined diatomaceous silica, a new and improved Superex insulation block which will safely withstand temperatures up to 1900°F was developed. A lower density and greater insulating value are claimed for it. E.J.V.

Testing of mortars for coke ovens. F. HARTMANN. *Glückauf*, **69** [25], 553–60 (1933).—Different kinds of mortars used for coke ovens were investigated by 16 testing methods to find out the method best suitable to test the particular requirements on a mortar for this purpose. Behavior at fusion, velocity of sintering, and fineness of mortar are the most important properties required. M.H.

Thermal conductivity of silica aërogel. S. S. KISTLER AND A. G. CALDWELL. *Ind. Eng. Chem.*, **26** [6], 658–62 (1934).—An apparatus is described for the measurement of heat conductivities of materials under variable mechanical and air pressures. Silica aërogel powders of different sieve analyses were measured and found to possess the lowest heat conductivity of any insulator so far reported at atmospheric pressure. The average value for the aërogel powder is 10% less than that for still air. The conductivity in vacuum is only 15% of normal. Mechanical pressure up to 15 lb./sq. in. does not greatly increase the conductivity in vacuum. An explanation of the very low conductivity is given, and suggestions for commercial utilization, especially high-temperature insulation, are considered. Illustrated. See also *Ceram. Abs.*, **13** [6], 157 (1934). F.G.H.

Thermal insulation of high-temperature furnaces. H. P. *Verre & Silicates Ind.*, **5** [7], 126–30 (1934).—Calculations are given showing the loss of heat through crowns of high-temperature furnaces. The effect of thermal insulation is discussed and its advantages are enumerated. M.V.K.

Why test raw refractory materials? W. MIEHR. *Sprechsaal*, **67** [13], 183–85; [14], 199–202 (1934).—After a historical review of the development of the refractories industry, an account is given of investigations and testing methods of raw materials and semifinished and finished products. Standardized testing methods are discussed. The importance of testing is pointed out. Bibliography. M.V.K.

BOOK REVIEW

Manufacture of corundum and silicon carbide and their application. G. M. IPPOLITOV AND E. P. KAKUSHADZE. State Sci. Tech. Pub. House of Machine Building, Metal Treatment, and Ferrous Metallurgy, Moscow and Leningrad, 1933. 104 pp., 21 figs. Price 2 R, 25 kopecks. After a short introduction on the development of the use of abrasive materials, particularly in the U.S., and a discussion on the properties of natural and artificial abrasives, a detailed description is given of the modern methods of silicon carbide and corundum manufacture. The last 16 pages are devoted to an outline of the use of these two abrasives for grinding-wheel manufacture and of the application of corundum. The fineness of the wheels, their hardness, bonds (ceramic, organic, and mineral) used for the preparation, and abrasive papers and cloths are briefly described. The book is of practical value and is the only one in the U.S.S.R. completely devoted to the manufacture of the two kinds of abrasives which are being used increasingly in the manufacture of refractories and super-refractories. S.I.PERKAL

BULLETINS AND BOOK

Bauxite industry in 1933: advance summary. ANON. *Bur. Mines Mineral Market Report*, MMS 268. 2 pp. Free. R.A.H.

Gas permeability as a method for testing grog bodies. YU. KVASHENINNIKOV AND K. KUMANIN. *Trans. Ceram. Research Inst.* [Leningrad], No. 40, 32 pp. (1933).—The gas permeability of grog bodies is much more affected by factors of operation than by their porosity and shrinkage. The higher the firing temperature, the greater is the gas permeability. The gas permeability and capability of absorbing water increase with the size of grog grains, while shrinkage decreases very little. The addition of clay to the grog mix lowers the gas permeability and water absorption but increases the shrinkage. M.V.K.

Graphite (Le Graphite). RENÉ SAUFFRIGNON. Part I. Technical Study, 50 pp. Part II. Economic Study, 58 pp. Published by Mines, Carrieres, Grandes Entreprises, Paris, 1933. Price 10 F. each. Reviewed in *Chem. Trade Jour.*, **94** [2442], 176 (1934).—The technical section is largely a summary, but comprises in 36 pages of text a remarkable amount of useful information. The economic section is particularly noteworthy for the amount of detailed information given on the uses of graphite. See also *Ceram. Abs.*, **13** [2], 40 (1934). M.V.K.

Investigation of some American refractory brick and cements. YA. V. KLYUCHAROV. *Trans. Ceram. Research Inst.* [Leningrad], No. 41, 40 pp. (1933).—A series of American refractory brick and cements was analyzed, subjected to various tests, and compared with similar products made of Russian raw materials. The researches show the possibility of replacing American refractories by refractory products manufactured in Russia. M.V.K.

PATENTS

Alumina. GINO GALLO. Ger. 588,583, Nov. 20, 1933. Pure Al_2O_3 is obtained by the electrolysis of the soluble products obtained by decomposing materials such as leucite containing Al_2O_3 and alkali with H_2SO_4. The electrolysis is continued until the Al_2O_3 and alkali form an alkali aluminate, and other substances present, such as Fe, Ca, and Mg, are precipitated as hydroxides. The aluminate solution is separated and worked up to pure Al_2O_3 and alkali salt by the usual methods. Examples are given. (*C.A.*)

Decomposition of siliceous aluminiferous minerals. A. L. MOND (Chemische Fabrik Buckau). Brit. 409,710, May 16, 1934.

Fireproof stone, etc. FELDMÜHLE, PAPIER- UND ZELLSTOFFWERKE A.-G., FRIEDRICH KLEIN, AND KARL BECHTEL. Ger. 588,805, Nov. 27, 1933. Crystallized metal oxides

such as Al_2O_3 or MgO are fused in an electric furnace and allowed to set. The resulting block is cut to desired shape by high-speed cutting tools. (*C.A.*)

Fireproof ware. GEWERKSCHAFT WESTEND. Ger. 524,534, Nov. 4, 1928; addition to Ger. 510,700, *Ceram. Abs.*, **10** [6], 441 (1931).—Glossy, impervious, fireproof stone objects are prepared from the clay, chamotte, flux mixture of 510,700 by preheating the plasticity-diminishing agent to 35 to 45%. The flux may contain 85% SiO_2. (*C.A.*)

Furnace wall construction. G. W. DAVEY. Brit. 409,560, May 9, 1934.

Furnace walls and blocks therefor. W. W. TRIGGS (Bernitz Furnace Appliance Co.). Brit. 409,827, May 16, 1934.

Glass. RENÉ AMAND. Fr. 755,171, Nov. 21, 1933. The construction of refractory pots is described. (*C.A.*)

Manufacture of alumina. ARTHUR FLEISCHER (Kalunite Co.). U. S. 1,960,336, May 29, 1934.

Method and apparatus for producing refractory bodies. BRITISH THOMSON-HOUSTON CO., LTD. Brit. 410,033, May 16, 1934.

Method and apparatus for producing refractory bodies. A. L. R. ELLIS AND G. A. F. WINCKLER (General Electric Co.). U. S. 1,960,215, May 22, 1934. The process of forming substantially homogeneous masses of refractory material from particles of the material consists in producing a flame by the combustion of combustible and combustion-supporting gases, the gases being delivered as a plurality of substantially parallel jets, the jets of one gas being intimately intermingled and closely adjacent to the jets of the other, uninterruptedly feeding the particles to be fused into the flame at a rate which is independent of the velocity of the gas currents, causing the particles to be spread at the input orifices of the jets in predetermined distribution with respect to the orifices, causing the flame to impinge on a foundation, and maintaining the delivery of the gases in such ratio and at such velocities that the particles will be fused solely by the flame within its impingement area upon the foundation.

Method of producing a coating of an oxide. BRITISH REFRACTORIES RESEARCH ASSOCIATION, A. GREEN, AND F. H. CLEWS. Brit. 402,203, Dec. 6, 1933.

Production or improvement of calcined magnesite and refractories containing it. ALTERRA A.-G. Belg. 395,717, May 31, 1933. Black or blackish brown, strongly ferromagnetic Mg ferrites or Ca ferrites which cause the formation of Mg ferrites are added to magnesite. (*C.A.*)

Refractory articles. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER (Eugen Rishkevich, inventor). Ger. 588,258,, Nov. 17, 1933. Refractory articles are manufactured by molding and firing a composition containing fresh ZrO_2 and calcined ZrO_2 together with up to 1.5% of BeO and about the same amount of MgO, with or without a little Al_2O_3. A part of the oxides may be formed *in situ* from hydrolyzable compounds, *e.g.*, $BeCl_2$, $ZrCl_4$, or $MgCl_2$. (*C.A.*)

Refractory brick. WALTER SCHROEDER. Ger. 590,227, Dec. 28, 1933. Binding clay in the form of a slip is mixed with sand, nonplastic clay, or other refractory substance to produce a viscous composition containing 10 to 25% of the binder. The mixture is forced into molds by mechanical means and fired. (*C.A.*)

Refractory and ceramic products. GEWERKSCHAFT WESTEND. Ger. 582,393, Aug. 12, 1933; addition to 524,534, "Fireproof ware," this issue, p. 214. In producing fire clay, stone products, etc., the total addition of flux and plasticity-diminishing agent is about 4%. (*C.A.*)

Refractory masses. ARTHUR SPRENGER. Ger. 587,827, Nov. 9, 1933. Oxides of Mg, Cr, and Al are fused in such proportions that the weight of the MgO equals or is greater than the sum of the weight of the Cr_2O_3 and Al_2O_3, the amount of Cr_2O_3 being greater than the amount of Al_2O_3. Other oxides such as SiO_2, CaO, FeO, etc., may also be present. Ger. 588,860, Nov. 29, 1933. The method of 587,827 for producing fireproof masses from MgO, Cr_2O_3, and Al_2O_3 is modified by replacing about $^1/_4$ of the MgO by lime-free SiO_2. See also Ger. 582,235, *Ceram. Abs.*, **13** [5], 124 (1934). (*C.A.*)

Refractory material. KLINKER- UND STEINZEUGWERKE MERTENDORF G.M.B.H. Ger. 590,295, Dec. 28, 1933. A mixture of quartz sand with about 10% of metallic Fe is heated in a reducing atmosphere to 1300 to 1500°. The mixture may be heated as such or in the form of balls prepared with the aid of a binder. The product contains SiO_2 in a modification of low density and does not increase in volume when reheated. It may be molded with the aid of a binder and fired at 1280° or above, or it may be added, to the extent of 20% or more, to compositions for making refractory brick. (*C.A.*)

Refractory material resistant to acid and alkali. H. FRAUENFELDER AND H. AVELLAN (Aktiebolaget Amfibolit O. Y.). Swed. 77,783, July 11, 1933. Finely ground amphibole-asbestos rock or waste product obtained by the extraction of asbestos from such rock after moistening with water is pressed and without predrying is fired in known ways until it is through sintering. (*C.A.*)

Refractory products. GILBERT E. SEIL. Fr. 755,038, Nov. 18, 1933. A refractory product of chromite, in which the gangue of low melting point has been transformed into a refractory material, is made by intimately mixing the Cr ore and crystallized MgO, highly calcined, the MgO being present in amount above 12.5% (preferably 17 to 25%) of the total weight of the mixture, grinding and kneading the mixture, and molding and calcining the mass, preferably to about 1650°. (*C.A.*)

Refractory tile. C. A. HAHN AND F. L. HALL. U. S. 1,962,738, June 12, 1934.

Terra Cotta

Comparative investigation on tile for floorings. ANON. *Keram. Rund.*, **42** [5], 53–55 (1934).—Data on various flooring tile made of stoneware, clay, natural rock, and cement as to their chemical stability, weather stability, fireproofness, efflorescences, and electric conductivity are given. M.V.K.

Engobe technique. ALBERT BAIER. *Keram. Rund.*, **42** [8], 92–93 (1934).—Various methods for applying engobes and for obtaining different effects are discussed. M.V.K.

Improved method of drying roofing tile. ANON. *Brit. Clayworker*, **43** [504], 9–11(1934).—The drying is carried out in 8 corridors built in an old drying shed. Each corridor is about 45 ft. long, 9½ ft. wide, and 6 ft. high and has a capacity of 18,000 tile per day. The drying is by air heated by a direct-fired air heater. Test figures on the performance of the heater and drier are given. R.A.H.

Manufacture of cable-protecting brick. ANON. *Ton-ind.-Ztg.*, **58** [31], 378–79; [33], 400–401 (1934).—German specifications relating to the manufacture of brick employed for protecting cables underground and details as to their manufacture are given. M.V.K.

Water-tight terra cotta construction. ECKARDT V. ESKESEN. *Bull. Amer. Ceram. Soc.*, **13** [6], 154–62 (1934).

PATENT

Roofing and like tile. J. H. HUTCHINSON AND PIPES, LTD. Brit. 409,657, May 16, 1934.

White Wares

American vs. European tableware. ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **13** [6], 153 (1934).

Aristocratic china. ARTHUR S. VERNAY. *Arts & Dec.*, **41** [2], 10 (1934).—The technical definition of china is a hard vitreous porcelain, translucent and cold to the touch. The difference between china and earthenware and the different grades of ware depends upon (1) the chemical content of paste or body, (2) the glaze and its application, (3) the amount of heat in firing, and (4) quality of workmanship. There are two types of china, soft paste and hard paste. The elements of hard paste are (1) kaolin or china clay, (2) feldspar, and (3) silica with varying amounts of others. Chinas with a high per cent of feldspar are more translucent, since feldspar melts and vitrifies in intense heat while kaolin dissolves in the glassy matrix. Fine English ware substitutes bone dust for some of the feldspar giving bone china, a ware between the other two in hardness and much prized. Earthenware is made of various potter's clays, is not subjected to such high temperature, and is opaque and not so cold to touch. There was very little china in England before the Stuart Restoration. Illustrated. E.B.H.

Concentrated research on whiteware to combat importer's claims. ARTHUR S. WATTS. *Ceram. Ind.*, **22** [4], 198 (1934).—To promote the whiteware industry successfully there must be fundamental data on the service behavior and physical properties generally of all American whiteware in direct comparison with the foreign ware which is being imported. Test specifications should be developed and tests run so that brand names are unknown to the investigator. Foreign claims must be refuted or domestic ware must be improved to a point of superiority. E.J.V.

Grinding time and water content of glazes. WERNER SCHLENKERMANN. *Keram. Rund.*, **42** [2], 15–17 (1934).—Since the degree of fineness to which glazes are ground is of chief importance, the grinding time is important. Tables showing the grinding time of unfritted glazes and frits and the effect of the frit composition, granulation, and specific gravity of separate ingredients on the glaze are dealt with. The amount of water used is also discussed. M.V.K.

Influence of composition of the feldspar constituent on the properties of a porcelain body. JOSEPH H. CHILCOTE. *Jour. Amer. Ceram. Soc.*, **17** [7], 203–204 (1934).

Manufacturing porcelain cups. EDWIN RIESS. *Keram. Rund.*, **42** [8], 99–100 (1934).—Each process in the manufacture of porcelain cups is discussed in detail. M.V.K.

Metal porcelain. CARL RANCKE. *Keram. Rund.*, **42** [2], 20 (1934).—Practical suggestions for metal plating of porcelain ware are given. See also *Ceram. Abs.*, **12** [1], 4 (1933). M.V.K.

Modern insulators. STEATITE AND PORCELAIN PRODUCTS, LTD. *Elec. Rev.*, **114** [2946], 662 (1934).—In coping with atmospheric pollution as a cause of overhead line troubles, this company has designed ceramic insulators to take care of fog, salt, cement, pulverized fuel dust, soot, tar, chemicals, and insects. The governing principle in most cases is the effective exposure of as large a surface as possible to the cleansing action of wind and rain. Such surfaces are made vertical where possible to take fuller advantage of horizontal winds than does the ordinary suspension insulator disk, the underside of which often becomes grime-coated. One type transfers the ribs to the top surface of the insulator. In the inclined disk insulator, the rain shed is mounted at an angle to the axis allowing wind and rain to reach both surfaces. The deep-shed insulator has a long exposed vertical surface which remains clean under the worst atmospheric conditions. A cylindrical metal collar cemented outside the hub of the insulator removes the bursting stresses sometimes exerted by the older type which uses a pin cemented inside the porcelain. Switchgear bushing covers standing 6 ft. high suffered a 14-in. contraction in drying and firing. A new ceramic material, "Frequentite," of very low power factor is mentioned. It possesses the characteristics of steatite including high mechanical strength and adaptability to die-pressing and extruding or otherwise forming into complex shapes with good dimensional accuracy in the finished article. J.L.G.

"Pock formations" in porcelain. ANON. *Keram. Rund.*, **42** [5], 58 (1934).—An interesting case of the formation of pocks on porcelain ware after the finishing firing is described. The defects were found to be due to the use of highly plastic clay rich in humus which gave up its water content only under certain conditions. The defects were avoided by proper firing. M.V.K.

Pottery and what the public wants today. R. COPELAND. *Pottery Gaz.*, **59** [684], 715–18 (1934).—C. gives a brief history of the development of the industry in England and lists the layman's particular requirements of

present-day pottery. More coöperation between manufacturers and retailers is needed. Simplicity of design combined with beauty of shape will be the keynote of the future. E.J.V.

Practical notes on the fabrication of porcelain. MARC LARCHEVÊQUE. *Céram., Verrerie, Email.*, **1** [7], 341–45 (1933).—L. presents some practical notes on screening and preserving porcelain slips and glazes. M.H.B.

Reasons for the use of auxiliary fluxes in whiteware bodies. ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **13** [6], 162–63 (1934).

Researches on the amorphous state. I. Dielectric losses in amorphous solid insulators. P. P. KOBEKO. *Phys. Z. Sov. Union*, **4** [1], 82–96(1933). **II. Electric conductivity of amorphous bodies in the softening interval.** P. P. KOBEKO AND J. G. NELIDOW. *Ibid.*, **4** [3], 516–30 (1933). **III. Dielectric constants of amorphous bodies in the softening interval.** P. P. KOBEKO AND E. KUWSCHINSKY. *Ibid.*, **4** [4], 680–94 (1933). **IV. Electric conductivity of mixtures in the softening interval.** P. P. KOBEKO AND J. G. NELIDOW. *Ibid.*, **4** [4], 694–702 (1933). **V. Relationship between the coefficients of temperature of the electric conductivity and the viscosity of amorphous bodies.** *Ibid.*, **4** [4], 703–708 (1933); abstracted in *Sprechsaal*, **67** [17], 252 (1934). M.V.K.

BOOK REVIEW

English Pottery and Porcelain. W. B. HONEY. A. & C. Black, Ltd., London, 1934. Price $2.50. This book is a concise but very complete and readable history of English ceramic ware. It is divided into parts as follows: (I) Earthenware and stoneware to the end of the 18th Century, (II) English porcelain of the 18th Century, and (III) 19th Century pottery and porcelain. The first chapter is devoted to the pottery of the 13th Century with its crude raw lead glazes sometimes colored green or brown with copper or iron ores. Slip-decorated ware and other peasant pottery of the 17th Century and later are described, and methods of producing the slip decorations, as well as the originators of the various types, are dealt with. English majolica and Delftware of the 16th to 18th Centuries, stoneware and early researches after porcelain, and the ceramic development of Staffordshire are discussed. Seven chapters are devoted to the famous producers of English china in historical order. These are rich in data of interest to the practical and technical ceramist as well as to the historian. The portions dealing with china bodies and their development from the frit bodies of the early French style to the English bone china of today are treated in a highly satisfactory manner.

Nineteenth and twentieth century pottery and bone china (the latter termed by the author a hybrid porcelain) are described. Much space is devoted to decorative styles and processes originated in various potteries. The book closes with a chapter on "collecting" and an excellent bibliography and index. ARTHUR S. WATTS

BULLETIN

Employing plagioclases in the ceramic industry. K. KÖHLER AND V. POPOVA. *Trans. Ceram. Research Inst.* [Leningrad], No. 39, 34 pp. (1933).—Researches show the following facts: (1) There is no difference between plagioclase and microcline bodies fired to cone 12 as to their shrinkage, melting temperature, and deformation under load at high temperature. (2) The vitrification of plagioclase bodies occurs later than that of microcline bodies, but proceeds more rapidly; the sintering process in both bodies is similar. (3) Bodies fired to cone 12 and composed of acid plagioclase have a higher crushing strength and greater transparency than bodies containing potassium feldspar. The mechanical strength and transparency of feldspar bodies decrease with increasing CaO content. (4) The linear expansion of plagioclase and microcline bodies is similar, and the microstructure of porcelain bodies containing acid plagioclase or microcline is similar; they show the same deformation when fired to cone 12. With an increased CaO content in feldspar the deformation decreases. Plagioclase bodies fired to higher temperatures than cone 12 (1350°) have a lower mechanical strength and a greater deformation. (5) Tests with microcline and plagioclase glazes show that their melting point and hardness are similar when fired to cones 12 and 13; when fired to cone 14, the plagioclase glaze is harder and has a better luster. M.V.K.

PATENTS

Electric insulating material. GASTON BROU. Fr. 755,794, Nov. 30, 1933. The vitrification of a ceramic product having a basis of Mg silicate is obtained by the addition of a nonalkaline borate, the combination of the constituents being regulated automatically and following the law of proportions defined by Proust by the volatilization of the excess of flux which does not enter into reaction. This method of working allows the firing to be carried out at an industrially economic temperature, avoiding, in particular, overfiring. Boracite or Mn borate is preferred. (*C.A.*)

Insulator. J. J. TAYLOR (Ohio Brass Co.). U. S. 1,961,402, June 5, 1934.

Radio spark plug. HECTOR RABEZZANA (A C Spark Plug Co.). U. S. 1,960,317, May 29, 1934.

Spark plug electrode with resistance in center wire. HECTOR RABEZZANA (A C Spark Plug Co.). U. S. 1,960,316, May 29, 1934.

Suspension insulator. WILHELM REGERBIS AND O. P. ZIESCHE (Hermsdorf-Schomburg-Isolatoren Ges. mit beschrankter Haftung). U. S. 1,960,190, May 22, 1934.

Water closets. F. R. DICKINSON. Brit. 409,426, May 9, 1934.

Equipment and Apparatus

Change of properties of die steels due to heat treatment. T. MURAKAMI AND A. HATTA. *Sci. Repts. Tôhoku Imp. Univ.*, **23** [1], 1–44 (1934). W.M.C.

Conditioning of clay in the plastic state. F. H. CLEWS. *Trans. Ceram. Soc.* [Eng.], **33** [1], 1–14 (1934).—This is the original reference; for abstract see *Ceram. Abs.*, **13** [2], 49 (1934). R.H.H.P., JR.

Dragline gives better clay-mix scooping up 118-ft. bank.

HERBERT J. FARR, JR. *Excavating Eng.;* reprinted in *Brick Clay Rec.*, **84** [5], 173 (1934).—Besides getting a better quality product due to the depth of the cut which crosses through several alternate layers of blue and yellow clay, the Cleveland (Ohio) Builders Supply Co. is saving considerable money in clay-winning expense by use of a dragline. Illustrated. E.J.V.

Drying by waste heat. CHARLES HILL. *Brit. Clayworker*, **43** [504], 13–15 (1934).—A description of kiln and drier operation as conducted by H. is given. R.A.H.

Efficient heat production and transfer in Lancashire and Cornish boilers. CHARLES F. WADE. *Brit. Clayworker*, **42** [503], 360–61 (1934).—W. discusses the internally fired cylindrical boiler showing that this type of boiler which was considered obsolete can be made highly efficient by proper operation and maintenance. R.A.H.

Evolution in steels. L. SANDERSON. *Brit. Plastics*, **5** [60], 559–60 (1934).—S. discusses (1) die steels, (2) cutting materials, and (3) chromium-plating of molds. G.R.S.

Experimental drier. ANON. *Brit. Clayworker*, **43** [505], 48 (1934).—A small experimental drier from which valuable data may be obtained is described. It is cheaply constructed and should pay for its manufacture by finding the best possible combination of heat and draft necessary to dry the product in the minimum of time without spoiling it. The drier is built around a 4-in. exhaust steam pipe, which is supplemented by a $^3/_4$-in. live steam pipe. The ends are closed with sliding dampers which enable close control of draft. R.A.H.

Heat-resistant metals and their use in the ceramic industries. SCHIRM. *Keram. Rund.*, **42** [9], 106–108; [10], 119–21; [11], 132–34 (1934).—The chief properties of heat-resisting metals and alloys such as (*a*) stability of shape, (*b*) resistance to slags, and (*c*) stability to changes of temperature are discussed in detail. According to composition these heat-resisting alloys can be classified into (1) chrome-nickel alloys, (2) chrome-nickel-iron alloys, (3) chrome-iron, (4) aluminum-iron, (5) chrome-nickel-aluminum-iron, and (6) iron-carbon alloys. The composition, properties, and use of these alloys are discussed in detail. Illustrated. M.V.K.

High temperature X-ray camera for quantitative measurements. A. H. JAY. *Z. Krist.*, **86** [1–2], 106–11 (1933).—A camera was designed for taking (at high temperatures) X-ray powder photographs which possess the qualities of those obtained at room temperature. Accurate measurement of line position is made possible. With a given heating current in the furnace the temperature of the specimen is known to within ±5°. G.R.S.

Laying out group drives. ROBERT W. DRAKE. *Factory Management & Maintenance*, **92** [5], 218–20 (1934).—New installations and extensive alterations are considered. Size of groups, new ideas about belt speeds which indicate that the best belt speed is nearer 2500 than 4500 ft./min., layout difficulties, pivoted bases, idler life, and quick changes are discussed. For previous abstract see *Ceram. Abs.*, **13** [7], 188 (1934). J.L.G.

Materials containing alkali metal salts found most efficient mold lubricants. PAUL C. LEMMERMAN. *Brick Clay Rec.*, **84** [5], 169 (1934).—A test of all known clay mold lubricants was conducted to find the ideal material. The efficient mold lubricants are all alkali metal salts of relatively weak acids which are capable of forming in aqueous solution polyvalent negative ions of greater ionic weight than the silicate (SiO_4) ion (76). Of the efficient materials listed sodium tetraborate (borax) and disodium phosphate are probably the only salts of interest commercially because of their low cost. E.J.V.

Measurement of quantities of material in operation. W. SCHULTES. *Glückauf*, **69** [34], 770–77 (1933).—The different systems of measuring quantities in continuous operation of solid, liquid, and gaseous materials are reviewed and theories explained. A number of less known and quite recent methods and instruments are described and illustrated, and sources of errors are pointed out. M.H.

Measuring conveyance for controlling temperature in tunnel kilns. PRADEL. *Messtechnik*, **9** [8], 154–56 (1934).—After discussing the principles and operation of tunnel kilns, P. describes a new conveyance supplied with measuring instruments. The results achieved were very satisfactory. Illustrated. M.V.K.

Novel continuous viscometer. CARL D. MILLER. *Instruments*, **6**, 2–3 (1933).—The Vismeter consists of a vertical conical journal which revolves at constant speed in a bearing containing a channel extending about 0.8 the distance around its face. The oil, flowing in the direction of revolution, enters one end of the channel; at the other end is a pressure gage, while about midway between is the oil outlet. The resulting pressure on the gage is read in centistokes and any other desired viscosity units. The theory is explained. Illustrated. (*C.A.*)

Petroleum—from well to consumer. F. J. SLEE. *Trans. Ceram. Soc.* [Eng.], **33** [4], 168–75 (1934).—A brief discussion of the refining of crude oil and the manufacture of heavy oils and greases together with recommendations concerning lubricants in use in the average brickworks is presented. R.H.H.P., JR.

Practical clayworking. XI. ANON. *Brit. Clayworker*, **42** [503], 347–49 (1934). **XII.** *Ibid.*, **43** [504], 4–5 (1934).—A discussion is given of drying in which the waste heat is conducted to drying sheds either through (1) ducts located under the floors or (2) sheet-iron ducts, the ends of which are placed at suitable points in the drying shed. The early quick-drying systems, the tunnel driers, and the humidity-controlled tunnel drier are also discussed. For Part X see *Ceram. Abs.*, **13** [5], 125 (1934). R.A.H.

Rapid drying of general earthenware. T. SIMPSON. *Trans. Ceram. Soc.* [Eng.], **33** [3], 85–91 (1934).—The construction and operation of an economical stove for the rapid drying of earthenware are described. R.H.H.P., JR.

Rapid method of dust sampling and approximate quantitation for routine plant operation. THEODORE HATCH AND E. WARD THOMPSON. *Jour. Ind. Hyg.*, **16** [2], 92–99 (1934).—A rapid and simple method of dust sampling and proportioning in industrial plants is essential to satisfactory operation of dust-control equipment. Great accuracy in the determination of dust content is not necessary and is secondary to speed and simplicity in the use of the measuring apparatus. A method is described. The Owens counter, modified to permit the collection of eight

samples on a single slide, is used as the sampling instrument, and the "dust ribbons" are quantitated by matching with dark field illumination against a series of standard ribbons under a comparison microscope. The method is calibrated in terms of the impinger. Illustrated. E.J.V.

Rules for operating the measuring devices in smelting plants. I. Blast-furnace plants. B. v. SOTHEN. *Stahl & Eisen*, **54** [11], 253–61; [12], 289–94 (1934).—S. deals extensively with instruments and equipment used for all measurements in blast-furnace plants. The most efficient arrangement for different purposes is discussed, both for centralized and decentralized plants. Measurements discussed include amount, pressure, temperature, and humidity of wind; pressure, temperature, and composition of blast-furnace gas; depth of furnace and number of charges; weight and transportation of charges; amount of air for combustion; and composition and temperature of waste gases. Instruments for measuring should be installed at the following places: blast-furnace proper, elevator for the charges, recuperators, and distributing places for the gases. Illustrated. W.M.C.

Sodium-vapor lamps in the clay industry. A. KARSTEN. *Tonind.-Ztg.*, **58** [29], 358–59 (1934).—Data on sodium-vapor lamps are given, and their use in the ceramic industry for illuminating purposes is discussed. Illustrated. M.V.K.

Studies in interferometry. I. New type of interference refractometer. W. E. WILLIAMS. *Proc. Phys. Soc.* [London], **44** [244], 451–64 (1932).—A new type of interferometer is described in which the beam from the central part of the collimator objective is divided and each half is laterally displaced. After passing through the gas tubes the beams are reunited so that the interference pattern at the focal plane of the telescope objective is similar to that from a two-plate transmission echelon. The brightness of the fringes is approximately 20 times greater than with the usual interferometer. A new method, based on Benoit's "fractional-part" principle, is developed. G.R.S.

Technique of measuring the shrinkage of ceramic and cement mixes. AD. POGANY. *Tonind.-Ztg.*, **58** [35], 428 (1934).—Details of a modified and improved Bauschinger shrinkage-measurer are given. Changes in length of samples up to 1/3000 mm. are easily measured. M.V.K.

Technique of stamping in the glass industry. L. DUBUIT. *Verre & Silicates Ind.*, **5** [8], 151–52 (1934).—The principles of stamping glass and ceramic ware and of various automatic machines are discussed. M.V.K.

Testing drying kiln. ANON. *Tonind.-Ztg.*, **58** [34], 418 (1934).—A new drying installation with a small output for testing materials is described. Illustrated. M.V.K.

PATENTS

Brick transferring apparatus. V. S. WALL AND C. M. WALL (North American Refractories Co.). U. S. 1,959,512, May 22, 1934.

Classifier. CHARLES HARRELL (J. B. Bates and H. E. Dixon). U. S. 1,959,917, May 22, 1934. A classifier separates liquids and solids or semisolids.

Machines for cutting brick and performing like operations. C. L. BENNETT. Brit. 409,892, May 16, 1934.

Material treating and handling equipment. S. L. DRYFOOS (Universal Sand Equipment Co.). U. S. 1,959,465, May 22, 1934.

Method and apparatus for preparing plastic (ceramic) materials for forming. BONNOT CO. Brit. 410,251, May 24, 1934.

Table feeder for crushed material. T. M. ALEXOVITS (J. E. Greenawalt). U. S. 1,960,522, May 29, 1934.

Kilns, Furnaces, Fuels, and Combustion

Charging roof tile in firing furnaces. G. A. *Ziegelwelt*, **65** [1], 2–4 (1934).—Details of firing and its effect on tile are discussed. M.V.K.

Collation of experimental data. IX. A. ALISON. *Glass*, **11** [4], 150–52 (1934).—A. describes the application of heat-capacity curves to combustion problems. **X.** *Ibid.*, **11** [5], 191–94 (1934).—The topics treated are specific heat, conversion of units, variation of chimney draft with altitude, relationship of barometric reading and altitude, and exponential laws of the form $y = ae^{bx}$. For Parts I–VIII see this issue, p. 222. A.J.M.

Combustion charts. A. R. SPREGA. *Calore*, **5** [6], 110–14 (1933); abstracted in *Bibliografia Italiana* [Series C], **6**, [11–12], 105 (1933).—S. discusses nomographic charts to be used in the control of combustion. H.F.V.

Combustion of low-grade fuels with addition of powdered coal. O. HALLER. *Glückauf*, **69** [41], 971–73 (1933).—Experiments have shown that a much better utilization of low-grade fuels can be obtained by injection of powdered coal for combustion. Examples are given. M.H.

Conceptions and characteristic numbers for judging sifting and classifying processes. W. LUYKEN AND L. KRAEBER. *Glückauf*, **69** [41], 957–61 (1933).—A report of the (German) committee on coal dressing reviews and suggests processes used for sifting and classifying coal and similar materials; formulas are developed for the calculation of different grades, and their application is illustrated by examples. M.H.

Conducting firing to avoid efflorescence. P. THOR. *Ziegelwelt*, **65** [2], 16 (1934).—A case is described in which the formation of efflorescences on brick was avoided by an appropriate firing. M.V.K.

Determination of the density of gas mixtures. JÜRGEN SCHMIDT. *Brennstoff-Chemie*, **15** [8], 146–47 (1934).—A method of calculating densities of gas mixtures based on the analyses of the mixtures and the densities of the pure gases is described. E.J.V.

Determination of the ignition temperature and the "humic acid curve" of a coal. J. W. KREULEN. *Fuel Sci. Practice*, **13** [2], 55–59 (1934). F.G.H.

Development of a simple approximation formula for

calculating the calorimetric temperatures of combustion. JULIUS LAMORT. *Feuerungstechnik*, **21** [3], 33–36 (1933).—The calculation of the theoretical temperature of combustion without taking into consideration the dissociation of water vapor, *e.g.*, the "calorimetric" combustion temperature, is of value for studying the processes occurring during firing of industrial furnaces. The formula is developed. M.V.K.

Developments in automatic stoking for brick kilns. M. STEENBRUGGE. *Trans. Ceram. Soc.* [Eng.], **33** [1], 15–20 (1934).—S. discusses the advantages of automatic stoking of top-fired kilns as opposed to hand firing. R.H.H.P., JR.

Electric resistance furnaces used in working steel. H. FEY. *Stahl & Eisen*, **54** [9], 210–12 (1934).—This is a review of modern types of electric-resistance furnaces. Details are presented for shaft kilns with and without protecting gas atmosphere, furnaces with removable heating top, different types of annealing furnaces, etc. Automatic temperature-control units such as provided in many furnaces are shown. W.M.C.

Factors affecting furnace heating practice. II. R. J. SARJANT. Presented at meeting of English Ceramic Society at Llandudno, May, 1934; abstracted in *Colliery Guard.*, **148** [3830], 990 (1934); for Part I see *Ceram. Abs.*, **12** [10–11], 358 (1933). E.J.V.

Firing equipment for unground coal dust. O. HALLER. *Glückauf*, **69** [4], 82–85 (1933).—A grate and nozzle arrangement is described which permits the burning of coal dust in boiler plants just as it comes from the mine. M.H.

Fuel for gas-fired kilns. ANON. *Brit. Clayworker*, **43** [505], 37–38 (1934).—Coals should possess the following properties to make them suitable for use in gas producers and gas-fired kilns: (1) The coal should not "blow" or expand excessively in the producer. (2) It should not tend to cake if this can be avoided or heat will be lost through pokering. (3) The volatile matter should be evolved between 300° and 600°C. (4) The fuel should produce a maximum of gas and tar in proportion to coke. (5) The gas produced should have a high calorific power. (6) The tar produced should be one which easily "cracks." (7) The ash content should not exceed 12% and should preferably be much lower. R.A.H.

Gas-analysis apparatus for the control of inerts in coal gas. J. G. KING. *Gas Engr.*, **51** [5], 229–30 (1934).—A detailed description of an apparatus for rapidly analyzing gas for nitrogen is given. It is possible to determine nitrogen content in 12 min. with this apparatus. Illustrated. E.J.V.

Greater production economy and better ware quality suggestions. EDITORIAL. *Bull. Amer. Ceram. Soc.*, **13** [6], 151–52 (1934).

Heat transfer in a turbulent flow. H. LORENZ. *Z. tech. Physik*, **15** [4], 155–62; [5], 201–206 (1934).—The heat transfer of liquids and gases flowing in pipes is presented in the form of graphs. The influence of a difference in temperature between the wall of the pipe and the liquid is discussed, as well as that of the length and surface properties of the pipe. Results of experiments for the passage of heat carried out by many investigators are presented and compared with theoretical formulas. W.M.C.

How to approach problems of propagation of heat under definite limits when the thermal properties of the system depend on temperature. P. VERNOTTE. *Compt. rend.*, **198** [18], 1584–86 (1934).—Distribution of heat and temperature conductivity are theoretically discussed for a body whose one face is suddenly brought to a different temperature. Application to numerical examples is illustrated. M.H.

Insure better periodic kiln firing with standardized schedule. ARTHUR J. BLUME. *Brick Clay Rec.*, **84** [6], 206–207 (1934).—The successful operation of periodic kilns depends on the proper combination of a few variables during water-smoking, oxidation, rising, and finishing periods. These are enumerated in detail. Illustrated. E.J.V.

Mathematical treatment of gas analysis. E. SCHRIEDER. *Feuerungstechnik*, **22** [4], 42–46 (1934).—Formulas are developed and applied to examples. M.V.K.

Microstructure of some Chinese anthracites. C. Y. HSIEH. *Fuel Sci. Practice*, **13** [2], 59–62 (1934). F.G.H.

Physical principles underlying the electric purification of gases. G. MIERDEL. *Z. tech. Physik*, **15** [5], 169–78 (1934).—The theory developed for the electric purification of gases is outlined. It is assumed that particles in suspension will be charged and will migrate, on account of the electric field, to the positive electrode. Secondary effects are explained by the presence of dust. The size of particles removed may vary from 0.01 to 150μ. Data are presented for the corona discharge, migration velocities of negative ions, and other factors of importance. Large plant units used in different industries for purifying gases are shown. W.M.C.

Precautions when "smoking" kilns. ANON. *Brit. Clayworker*, **43** [504], 20–21 (1934).—The increasing use of fans for improving the efficiency of the smoking period, during which the goods in a continuous kiln are "dried off," has led to several small defects being discovered. If an "accelerator" is attached to the wicket and is set to work without the damper connected to the hot-air flue being opened, the accelerator will exhaust the air from the chamber and will break the paper damper which separates the next adjacent chamber. The air withdrawn from this chamber either creates too strong a draft causing cracking of the ware or causes it to be discolored with scum. If the relative positions of the fan outlet and inlet for hot air are not properly adjusted, the hot air may be short-circuited and the "smoking" will be abortive. A common error is to distribute the air in such a manner that the lower courses of ware are not heated to the same temperature as the others and consequently are not properly dried. This is best avoided by tearing the lower part of the paper kiln in the next hotter chamber to permit some of the kiln gases to enter the lower part of the chamber. R.A.H.

Scientific utilization of gas. Further investigation of burner jets. W. J. G. DAVEY AND A. E. JONES. *Gas World*, **100**, 84 (1934); abstracted in *Fuel Sci. Practice*, **13** [2], 64 (1934). F.G.H.

Symposium on kiln firing proposed. R. C. PURDY AND EUGENE D. MILENER. *Bull. Amer. Ceram. Soc.*, **13** [6], 165–67 (1934).

BULLETIN

Possible production of low ash and sulfur coal in Illinois as shown by float-and-sink tests. DAVID R. MITCHELL. *Univ. of Ill. Eng. Expt. Sta. Bull.* No. 258 (Vol. 30, No. 44).—Basing conclusions on theoretical float-and-sink tests only, coal produced from the workable beds of Ill. is not particularly difficult to clean. Almost two-thirds of the total number of samples for which data are given show either a simple or an only moderately difficult cleaning problem. A low ash and, at some mines, a low-sulfur coal can be prepared equal to or better than any of the imported coals in these respects. Whether or not a coal shall be cleaned is largely an economic problem for the coal company to solve. A.K.

PATENTS

Firing ceramic articles. FRIEDRICH DETTMER (Porzellanfabrik Kahla, Zweigniederlassung Freiberg). Ger. 586,424, Oct. 21, 1933; addition to 530,269 (see following patent). The system described in Ger. 530,269 is modified by maintaining an atmosphere of CO_2 or other inert gas in the preheating chamber in which the oil vapors are evolved. (*C.A.*)

Tunnel kiln for ceramic goods shaped by pressure. LUDWIG WIRTH (Porzellanfabrik Kahla, Zweigniederlassung Freiberg). Ger. 530,269, Sept. 29, 1929. The kiln includes a separate preheating chamber in which the goods are indirectly heated, the press-oil vapors evolved from the goods being recovered. (*C.A.*)

Geology

Bauxite occurrence at Sümeg. TIHAMÉR GEDEON. *Földtani Közlöny*, **63**, 96–97 (1933).—Twenty-two analyses are published with a theoretical discussion. (*C.A.*)

Borax. GEORGE ELLIS. *Amer. Enameler*, **7** [3], 4–5 (1934).—The history of the word "borax," its meaning, and the mining and preparation of the raw material to make it of commercial value are presented. H.T.

Diatomaceous earth and its uses. R. O. UNDERWOOD. *Clay Prod. News*, **7** [5], 4–5 (1934).—U. explains what diatomaceous earth is and gives several uses for it. A.J.M.

Electrical methods of geophysical prospecting. J. MCGARVA BRUCKSHAW. *Jour. Inst. Elec. Eng.* [London], **73**, 521–41 (Nov., 1933).—A general discussion of the standard methods of geo-electrical prospecting, representing the best English practice of today, is given. (*R.S.I.*)

Genesis of the Sanntal bauxites (Jugoslavia). EMIL DITTLER AND OTHMAR KÜHN. *Chem. Erde*, **8**, 462–95 (1933).—The geology and mineralogy of the rock formations are described. The origin of the bauxite is in the weathering of andesite which had previously been altered by postvolcanic action. Unaltered, much younger Miocene andesite remained intact. A secondary mode of formation is in the deposition from solutions of Triassic limestone in contact with Al- and Fe-bearing solutions derived from the andesite. The Al_2O_3 is present mainly as the monohydrate, and its content varies from 59.34 to 74.43% dry basis. (*C.A.*)

Investigation into the commercial utility of a deposit of magnesite-bearing rocks in the Anglo-Egyptian Sudan. W. H. TYLER AND W. J. REES. *Trans. Ceram. Soc.* [Eng.], **33** [3], 104–27 (1934).—The authors report that sound brick can be manufactured from the Sudan rock if sufficient additional magnesium oxide is introduced to make the SiO_2/MgO ratio in the mixture richer in MgO than that of theoretical forsterite. They conclude from load tests that in firing the mixture some melt is formed, probably approximating in composition to clinoenstatite, which takes up MgO as the temperature rises and becomes more and more viscous until it freezes. Addition of iron oxide to the mixture tends to lower the softening-point in the silicate bond. R.H.H.P., JR.

Mineralogical study of loess near St. Charles, Missouri ROSALIE T. OEFELEIN. *Jour. Sedimentary Petrology*, **4** [1], 36–44 (1934).—A mineralogical study of an exposure of buff loess overlying gray loess near St. Charles, Mo., indicates that the buff loess was produced by the weathering and oxidation of the gray loess and that the difference in color is due chiefly to the greater amount of iron oxide and iron-rich beidellite in the buff than in the gray loess. A comparison of this loess deposit with the profile of weathering described by Leighton and MacClintock as developed on the till deposits of Ill. indicates that this exposure of loess is an example of a youthful profile of weathering developed on loess. A.K.

Nomenclature of plagioclases. V. ROSICKY. *Z. Krist.*, **84** [3–4], 323–27 (1933).—Much confusion exists among various authors in naming the members of the plagioclase series of feldspars. A table shows the variation of percentages of albite and anorthite in the 10 feldspars of the series as indicated by 9 authors. A new system suggested has the following advantages: (1) It is based on chemical composition and physical properties. (2) The optical character, which is an important and easily determined property in thin sections, is used as a distinguishing feature. (3) It is easy, from the form of the isogyres, to determine if the axial angle $2V$ is near the value 90°. (4) The four groups into which the plagioclase series falls according to their optical characters play important rôles in different types of magmas. (5) The arbitrariness in the distribution of a single plagioclase mixture is at least done away with. G.R.S.

Optically uniaxial titanaugite from Aberdeenshire. B. E. DIXON AND W. Q. KENNEDY. *Z. Krist.*, **86** [1–2], 112–20 (1933).—An investigation was made of an optically uniaxial augite of high titanium content, and a discussion is given of the general problem of the rôle of titanium in the pyroxenes. G.R.S.

Petrographic study of clay minerals—a laboratory note. RALPH E. GRIM. *Jour. Sedimentary Petrology*, **4** [1], 45–47 (1934).—The individual clay mineral particles that compose clayey sediments are usually too small to permit their optical properties to be determined. A technique is described for obtaining aggregates of clay mineral particles in which all the individual particles have about the

same optical orientation so that the optical constants of the clay mineral can be measured easily and accurately. The problem presented by fine calcite, which masks the optical constants of the clay mineral and of which the removal is difficult without altering the clay mineral, is met by an improved method for eliminating fine calcite from calcareous sediments. A.K.

Pleochroic halos and the age of minerals. G. H. HENDERSON. *Phys. Rev.*, **45** [3], 216 (1934).—Using a microphotometer which measures the intensity of blackening in the pleochroic halos of biotite mica, H. calculates the age of the mica. Six rings are shown in a photomicrograph, the first 5 accounting for the 8 alpha particles of the uranium family and the 6th due to the actinium family. Comparison of the height of this hump with that due to RaC′ just outside it gives data used in calculating the age of the mica. J.L.G.

San Joaquin clay, California. W. F. BARBAT AND JOHN GALLOWAY. *Bull. Amer. Assn. Petroleum Geol.*, **18** [4], 476–99 (1934).—The post-Miocene sediments of the San Joaquin valley, with a total thickness of 14,000 ft., were deposited under varying conditions of marine, brackish, lacustrine, fluviatile, and subaërial sedimentation. The sediments may be divided into three main divisions based on their lithologic character, fossil content, and diastrophic history. The three divisions comprise cartographic units of formational value. The post-Miocene formations are (1) the Tulare formation (Pleistocene), consisting of lacustrine, fluviatile, and subaërial sediments; (2) the San Joaquin clays (late Pliocene and early Pleistocene), consisting of lacustrine, brackish, and marine alternations; and (3) the Etchegoin sand (Pliocene), which is marine. The San Joaquin unit is discussed in detail and a tentative correlation of the San Joaquin clay is attempted. G.M.H.

Structure of edingtonite. W. H. TAYLOR AND R. JACKSON. *Z. Krist.*, **86** [1–2], 53–64 (1933).—The structure of edingtonite was determined with the help of data obtained from Laue and rotation photographs. The symmetry is tetragonal to a close approximation but is probably really orthorhombic; the departure from truly tetragonal symmetry is due to the different sizes of the SiO_4 and AlO_4 groups. The structure is based upon a continuous framework of tetrahedra formed by linking together in a simple way strings of tetrahedra similar to those formed in natrolite, scolecite, mesolite, and thomsonite; edingtonite should therefore be regarded as the first member of this group of fibrous zeolites. G.R.S.

Thermal analysis of soils of Tunis. V. AGAFONOFF AND G. JOURAVSKY. *Compt. rend.*, **198** [15], 1356–58 (1934).—Stratification of clay- and kaolin-containing soils was determined and charted. M.H.

BOOKS AND BULLETINS

Abstracts of current articles on geophysical prospecting. F. W. LEE. *Bur. Mines Periodical Service Rept.*, GA 57; GA 58, 21 pp.; GA 59, 24 pp. 10¢ each. See also *Ceram. Abs.*, **13** [5], 131 (1934). R.A.H.

Elements of Optical Mineralogy. II. Descriptions of Minerals. A. N. WINCHELL. 3rd ed. 459 pp., 361 figs. John Wiley and Sons, New York, 1933. Price $6.00. Briefly reviewed in *Econ. Geol.*, **29** [1], 100 (1934).—New classifications for silicates based on X-ray studies have been added to the arrangement of the earlier editions. New correlations and diagrams arising from the relations between optical properties and chemical composition have been included. New minerals have been added and the section on amphiboles has been revised. J.L.G.

Flotation of Alabama graphite ores. B. W. GANDRUD, G. D. COE, C. S. BENEFIELD, AND I. N. SKELTON. *Bur. Mines Rept. of Invest.*, No. 3225, 20 pp. Free. Results are given of an investigation undertaken to develop a concentrating process capable of recovering at low cost the maximum amount of graphite meeting requirements for the manufacture of dry batteries. R.A.H.

Historical Geology. WALTER A. VER WIEBE. 162 pp., 206 figs. Photolithoprint of author's manuscript. Edwards Bros., Inc., Ann Arbor, Mich., 1934. Paper. Listed in *Bull. Amer. Assn. Petroleum Geol.*, **18** [4], 557 (1934). G.M.H.

Microscopic determination of the nonopaque minerals. E. S. LARSEN AND HARRY BERMAN. 2nd ed. *Geol. Surv. Bull.*, No. 848; for review see *Ceram. Abs.*, **13** [7], 196 (1934). R.A.H.

Mineral resources of the United States, 1931. II. Nonmetals. 675 pp. Bur. Mines bound volume of individual chapters on mineral resources of the U.S. Price $1.00 from Supt. of Documents, Govt. Printing Office, Washington, D. C. R.A.H.

Outlines of Physical Geology. CHESTER R. LONGWELL, ADOLPH KNOPF, AND RICHARD F. FLINT. John Wiley and Sons, Inc., New York, 1934. 356 pp., 157 figs. Price $3.00 net, cloth. Listed in *Bull. Amer. Assn. Petroleum Geol.*, **18** [4], 557 (1934). G.M.H.

Chemistry and Physics

Analysis of borax. ANON. *Amer. Enameler*, **7** [2], 3 (1934).—The evaluation of borax is simplified by the fact that boric acid reacts neutral to indicators such as methyl orange, methyl red, and paranitrophenol but reacts acid to phenolphthalein. With the aid of glycerol or mannitol, using phenolphthalein as the indicator, the boric acid can be determined by titrating with standard alkali solution. A 0.5 normal solution of sodium hydroxide free from carbonate, is suitable for the determination of boric acid. A 0.5 normal solution of sulfuric or hydrochloric acid is suitable for the determination of the alkali. H.T.

Analysis of gases and fumes. ANON. *Verre & Silicates Ind.*, **5** [6], 106–108; [8], 149–51 (1934).—After discussing the importance of analyzing gas and fumes, the technique of analysis, automatic controlling apparatus with a physical and chemical action, and electric gas analyzers are described. M.V.K.

Analysis of litharge. ANON. *Amer. Enameler*, **7** [3], 4 (1934).—The procedure of analyzing litharge to determine the suitability for high-grade porcelain enamels is described. H.T.

Base exchange in relation to composition of clay with special reference to effect of sea water. W. P. KELLEY AND G. F. LIEBIG, JR. *Bull. Amer. Assn. Petroleum Geol.*, **18** [3], 358–67 (1934).—The term "base exchange," as commonly used, refers to the alteration in cation composition of a solid resulting from treatment with a salt solution. Certain types of clays are especially reactive, treatment with ocean water producing notable cation exchange. Sodium is the dominant base of ocean water, but magnesium plays a greater part in base exchange with clays. Samples of soils and a bentonitic clay treated with ocean water have been found to contain more replaceable magnesium than replaceable sodium. On the other hand, Taylor and Case report that clays overlying oil deposits contain little replaceable magnesium and relatively much replaceable sodium, indicating that oil-field clays have been in contact with salines quite different from ocean water. The composition of oil-field brines is in harmony with this conclusion. It is possible, however, that the base-exchange constituents of the oil-field clays have undergone molecular rearrangement or crystallization since being deposited in ocean water, resulting in magnesium passing into non-replaceable forms. G.M.H.

Collation of experimental data. I. A. ALISON. *Glass*, **10** [6], 246–47(1933).—A. explains in general some of the dangers of interpolation and extrapolation. **II, III, IV, and V.** *Ibid.*, **10** [7], 284–86; [9], 371–73; [10], 422–25; [11], 466–69 (1933); see also *Ceram. Abs.*, **13** [3], 73 (1934) in which Parts III, IV, and V are incorrectly numbered Parts II, III, and IV. **VI.** *Glass*, **11** [1], 22–24 (1934).—A. describes several polynomials to be used in drawing experimental curves. The formation of tables of differences is explained and examples are given. **VII.** *Ibid.*, **11** [2], 68–70 (1934).—A. explains how to obtain the equation of a data curve by the method of differences. **VIII.** *Ibid.*, **11** [3], 102–103 (1934).—An explanation of the construction and use of heat-capacity curves is given. For Parts IX and X see this issue, p. 218. A.J.M.

Colorimetric determination of magnesium. L. DEBUCQUET AND L. VELLUZ. *Bull. Soc. Chim.*, **53**, 1291–92 (1933); abstracted in *Analyst*, **59**, 200 (1934). H.H.S.

Colorimetric determination of nickel in cobalt salts by formaldoxime. G. DENIGÈS. *Bull. Soc. Pharm. Bordeaux*, **21**, 106–107 (1932); abstracted in *Analyst*, **59**, 200 (1934). H.H.S.

Crystallization of vitreous substances. P. MONDAIN-MONVAL. *Compt. rend.*, **198** [16], 1413–15 (1934).—Experiments with S and Se showed the existence of a certain temperature where a sudden change of their physical properties takes place, the same as in glasses; this occurs in S at −29°C and in Se at +32°C. These temperatures coincide with the temperature which is the limit of their crystallization in the vitreous state and below which the crystalline modification of the substances can no longer appear. M.H.

Dehydration heat of clay. H. ELSNER V. GRONOW AND H. E. SCHWIETE. Presented at meeting of the Kaiser Wilhelm Inst. for Silicate Studies, 1933; abstracted in *Sprechsaal*, **67** [5], 60 (1934); *Keram. Rund.*, **42** [4], 44 (1934); for abstract see *Ceram. Abs.*, **13** [4], 101 (1934). M.V.K.

Detection of crystals in glasses. W. BUSSEM. Presented at meeting of the Kaiser Wilhelm Inst. for Silicate Studies, 1933; abstracted in *Sprechsaal*, **67** [5], 61 (1934); *Keram. Rund.*, **42** [4], 45–46 (1934).—"Detection of crystals" is a problem of great importance to glass practice and theory. Quantitative determination of kinds of crystal precipitates in opacified glasses and enamels may be made by X-rays. This identification depends on a series of factors each of which is discussed with practical examples. In addition to "quantitative crystal analysis," another method can be used in which the line of the ratio of intensity to the "underground" is evaluated. The intensity of the crystalline line and the underground are directly proportional to the quantity contained by a sample, and the specific intensity of the line is greater, the higher the "number of classification" of the atom. The difficulty of identifying very small crystals consisting of a small number of atoms is explained. The identification of crystals in glasses depends on the specific capability of dispersion of crystals and glasses. It is easier to detect a crystal with heavy atoms and a glass with light atoms than the converse. The greatest sensitivity is obtained with monochromatic light. M.V.K.

Determination of alkalis as silicofluorides. W. D. TREADWELL AND W. KÖNIG. *Helv. Chim. Acta*, **16**, 1201–1208 (1933); abstracted in *Analyst*, **59**, 132 (1934). H.H.S.

Determination of easily soluble phosphoric acid and potash in soils by extraction with water and with carbonic acid-bicarbonate solutions. B. DIRKS AND F. SCHEFFER. *Superphosphat*, **6**, 75–80 (1930).—It is proposed to determine easily soluble P_2O_5 and K_2O in acid soils by extraction with distilled water, and in neutral and alkaline soils by extraction with a H_2CO_3 solution of $Ca(HCO_3)_2$. Thirty grams of the soil are shaken with 75 cc. of water, or the soil is mixed with 1 g. of $CaCO_3$ and shaken with 75 cc. of solution containing CO_2 equivalent to 80 cc. of 0.1 *N* NaOH per 100 cc., for 1 hr. continuously in a 100-cc. flask. P_2O_5 in the filtrate is determined by the Mo-blue method, and K_2O is determined by the cobaltinitrite method. The method gives results which usually parallel those obtained by the Neubauer seedling method, although the actual numerical values obtained by the two methods may be quite different. Results obtained with the method on soils receiving the same fertilizer treatment over a period of years are tabulated, and the use or non-use of P_2O_5 and K_2O fertilizers is definitely indicated by the data. (*C.A.*)

Determination of traces of bismuth in presence of other metals. L. A. HADDOCK. *Analyst*, **59**, 163–68 (1934). H.H.S.

Determining fluorine by means of chlorofluoride of lead. J. FISCHER. *Ind. chimique*, **20** [237], 785 (1933).—The determination of fluorine in the form of chlorofluoride of lead according to the modified method of Stark yields good results. The presence of silica is not harmful. The determination of fluorine in the presence of sulfates and phosphates, which previously was made indirectly, can

be easily made by distilling fluorine with perchloric acid. Small quantities of fluorine (20 mg.) can be determined with sufficient precision (−2%). M.V.K.

Directional effect and light phenomena in silicon carbide crystals. BRUNO CLAUS. *Ann. Physik*, **11**, 331–56 (1931).—A detailed study is made of the effect of contact pressure and surface electrical charges in a detector consisting of a Cu point and a SiC crystal. The so-called directional effect arises in the interfacial layer between point and crystal. By using 50-cycle a. c. and field strengths of 3.0 × 10 v./cm. and varying the mechanical pressure, the direction of the current components was determined. Concurrently, the effect of temperature (to −180°) on this effect and the appearance of yellow and blue patches on the negative and positive points were studied. These glows have a continuous spectrum and occur only for low contact pressures and voltages of 4 to 20. They are indicative of the existence of areas of extremely high surface conductivity. (*C.A.*)

Distinction between magnesium absorbed and that exchangeable four years after lysimeter incorporations of oxides and carbonates. W. H. MACINTIRE, W. M. SHAW, AND B. ROBINSON. *Soil Sci.*, **37** [4], 289–303 (1934).—The quantity of magnesium absorbed from 32-ton additions was much greater than that found for 8-ton treatments, but the minimal absorption greatly exceeded the exchange capacity. The absorbed magnesium was found to be resistant to 8 successive leachings and to 4 successive extractions with a normal solution of ammonium chloride, the values obtained by the two procedures being comparable. Dilute acid extractions were more efficacious than either leachings or extractions with ammonium chloride in effecting recoveries of absorbed magnesium. A definite increase in the alumina dissolved from the magnesia-treated units indicated that the added magnesium had disrupted the aluminum complex. Since both the lysimeter history and the laboratory determinations for each soil unit showed that neither calcium nor potassium had been replaced by the added magnesium, the magnesium absorptions are accounted for only by hydrogen replacement, but the exchangeable hydrogen by the conventional methods was only $^1/_{10}$ the equivalent of the maximal magnesium absorption. Hence, in relation to and confirming results from a different method of attack, it was concluded that in the soil system are two types of acid complexes. One reacts readily with economic quantities of magnesic materials to form exchangeable complexes, whereas the other type will react much more extensively with excessive incorporations over an extended period to form absorption complexes not measurable by conventional methods, although measured by successive agitated extractions with 0.02 *N* nitric acid. G.R.S.

Effect of superphosphate on the reaction, base saturation, and buffering power of acid mineral soils. LUDWIG SCHMITT. *Superphosphat*, **6**, 219–27 (1930).—A number of field experiments over a period of years showed that superphosphate behaves in the soil as a physiologically neutral salt and has practically no effect on the reaction, base saturation, and buffering power of acid mineral soils. (*C.A.*)

Electrodialysis as a means of studying the nature of soil phosphates. L. A. DEAN. *Soil Sci.*, **37** [4], 253–66 (1934).—In this study the following points were covered: (1) the electrodialysis of readily and difficultly soluble phosphate compounds, (2) the total quantity of phosphate removed by electrodialysis as compared to that removed by Truog's method of acid extraction, and (3) the nature of the difficultly soluble phosphates present in soils. G.R.S.

Establishment of a scale of color temperature. H. T. WENSEL, D. B. JUDD, AND WM. F. ROESER. *Bur. Stand. Jour. Research*, **12** [5], 527–36 (1934); R. P. 677.—A number of 400-watt projection lamps were color-matched with black bodies immersed in freezing platinum, rhodium, and iridium. From these lamps working standards of color temperature were prepared, interpolation between the three fundamental points being accomplished by making use of systematic differences between the color temperature of the lamp and the brightness temperature of the inside of a particular turn of the coiled tungsten filament. These working standards embody a reproducible scale of color temperature which is consistent with the International Temperature Scale within 5°K everywhere in the range from 2000 to 2800°K. The new scale assigns higher values to any given source than the scale previously used at the Bureau of Standards which was supposed to be the same as the Nela scale of color temperature. The differences are 22°K at the platinum point and 14°K at the rhodium and iridium points. R.A.H.

Fluoride determination by the spectrophotometric method. R. FABRE AND S. BAZILLE. *Jour. Pharm. Chim.*, **18** [11], 465–70 (1933); abstracted in *Analyst*, **59**, 125–26 (1934). H.H.S.

How litharge is made. MILES M. ZOLLER. *Amer. Enameler*, **7** [2], 6 (1934).—The complete history of the manufacture of lead and litharge is given. H.T.

Melting diagrams of the systems KF–AlF_3 and LiF–AlF_3. P. P. FEDOTIEFF AND K. TIMOREEFF. *Z. anorg. allgem. Chem.*, **206** [3], 263–66 (1932); abstracted in *Physik. Ber.*, **13** [20], 1859 (1932). M.H.

Method and experimental apparatus for measuring refractive indices of substances in molten state. C. SALCEANU. *Bull. Acad. Roumaine*, **16** [1–3], 8–12 (1933); *Physik. Ber.*, **15** [7], 528 (1934).—The indices are determined by the Fraunhofer method and the three prisms used in it are placed in an electrically heated chamber with windows in which the substances (of low melting point) are melted. M.H.

Migration method for the determination of replaceable bases in soils. L. C. WHEETING. *Soil Sci.*, **37** [4], 243–52 (1934).—Three methods for the extraction of replaceable bases from soils were compared on a group of 10 soils, 4 of which contained carbonates. The methods were the 0.1 *N* $BaCl_2$ leaching method of Burgess and Breazeale, the normal ammonium acetate leaching method of Chapman and Kelly, and a newly devised migration method for extraction after treatment of the soil with hot normal ammonium acetate solution. The results show a preferential extraction of alkaline earth bases over alkali bases in the case of the leaching methods, if the results obtained by migration procedure are considered as a basis for judgment. Since the migration method does not appreciably change the p_H value of the soil during extraction or bring about excessive solubilities through leaching, it seems to do

away with the worst features of other methods, including electrodialysis. The results of the migration method show that the present ideas, based upon leaching and other methods, regarding the ratios of replaceable bases in soils must be revised. There is generally more sodium and magnesium in replaceable form in the soils than has formerly been obtained through the use of the usual methods of extraction. Use of the migration method may probably be made in connection with anion studies in soils.

G.R.S.

New colorimetric method of determining lead. S. Feinberg. *Z. anal. Chem.*, **96** [11–12], 415–18 (1934).—The method is based on the principle of dissolving the lead in molybdic acid and determining the molybdenum in the solution colorimetrically. The method can also be used for colorimetric determination of small amounts of copper as well as cadmium. E.J.V.

Photoelectric effect in specially active layers of silicon-carbide crystals. O. V. Losev. *Jour. Tech. Phys.* [U.S.S.R.], **1**, 718–24 (1931). (*C.A.*)

Preparation of coloring oxides in the ceramic industry. Fried. Bigot. *Rev. mat. constr. trav. pub.*, No. 294, pp. 41–47*B* (1934).—Various ways for preparing coloring oxides and pigments for enamels and ceramic products are discussed. Factors affecting the development of colors, such as composition, physical state, mixing, firing and kilns used, and grinding, are discussed in detail. Compositions of blue, French green, olive green, brown-red, copper-green, blue slate, and yellow are given. M.V.K.

Principles underlying the drying of clay. H. H. Macey. *Trans. Ceram. Soc.* [Eng.], **33** [3], 92–103 (1934).—The drying and shrinkage of clay takes place in two stages. During the first stage the rate of drying remains constant and the greatest amount of shrinkage takes place; during the second stage the rate of drying falls off continuously. Drying strains and the resultant surface cracks are dependent upon (1) the rate of drying or the rate at which water flows to the surface and (2) the resistance of clay to the water flow. R.H.H.P., Jr.

Quantitative determination of air content in plastic clay or porous bodies. G. W. Lapp. *Jour. Amer. Ceram. Soc.*, **17** [7], 204–208 (1934).

Soaking of porous substances by liquids. Paulette Berthier. *Compt. rend.*, **198** [18], 1607–1609 (1934).—A formula is developed for calculating the rise of liquids in porous substances; application is illustrated for the case of filter paper. M.H.

Stabilization of mineral suspensions. I. Relation between the stabilizer and the stability of the suspensions. L. V. Lyutin. *Jour. Phys. Chem.* [U.S.S.R.], **4**, 299–304 (1933).—Data are given for adsorption by kaolin, talc, glass powder, graphite, S, Fe_2O_3, and Al_2O_3 stabilized with tannin, gelatin, albumin, and gum arabic. **II. Inorganic colloids as stabilizers of mineral suspensions.** L. V. Lyutin and G. V. Zakharova. *Ibid.*, **4**, 305–307 (1933).—Iron oxide adsorbed on graphite suspensions acts as a stabilizer. **III. Stabilizing action of organic dyes on graphite suspensions.** *Ibid.*, **4**, 373–79 (1933).—Data are given for adsorption and stabilizing action of a large number of dyes on graphite. Only colloidal or semi-colloidal dyes giving irreversible adsorption are effective, such as Congo red, aniline blue, eosin. (*C.A.*)

Structure of euclase, $HBeAlSiO_4$. J. Biscoe and B. E. Warren. *Z. Krist.*, **86** [3–4], 292–97 (1933).—From rotation and oscillation photographs made with a small splinter of euclase the unit cell and space group were determined: $a = 4.62$Å, $b = 14.24$Å, $c = 4.75$Å, and $\beta = 74° 44'$. The space group is C_{2h}^5 with glide along c and there are 4 molecules $HBeAlSiO_4$ per unit cell. Each Al is octahedrally surrounded by 5 oxygens and 1 hydroxyl, each Si is tetrahedrally surrounded by 4 oxygens, and each Be is tetrahedrally surrounded by 3 oxygens and 1 hydroxyl. The Pauling rule is obeyed exactly. G.R.S.

Studies in refractive index. I–II. A. M. Taylor and A. M. Glover. *Jour. Opt. Soc. Amer.*, **23** [6], 206–15 (1933).—(I) Methods of measurement. Four methods are described for measuring the refractive index of strongly absorbing liquids. The first two depend upon the determination of the critical angle of reflection of monochromatic light at a glass-liquid interface. In the third, white light reflected at angles near the critical angle was allowed to enter a spectrograph. Peaks in the record of a microdensitometer were found to correspond to maxima of the refractive index. In the fourth method the transmitted light was examined visually in a spectroscope. (II) The anomalous dispersion of potassium permanganate in aqueous solution. The four methods have been utilized in a study of a saturated solution of $KMnO_4$. A dispersion curve with a strong anomaly centering about 5473A together with a series of minor anomalies corresponding to the banded structure of the absorption spectrum was found. An approximate solution of the Drude-Lorentz dispersion equation agrees qualitatively with the observations. It is concluded that the band at 5473A is that caused by the fundamental frequency of an electronic transition in the manganese ion of the permanganate radical. **III. Penetration of the superficial wave at total reflection and optical evidence for the existence of adsorbed surface layers.** A. M. Taylor and Dorothy A. Durfee. *Ibid.*, **23** [8], 263–69 (1933).—Experiments are described which indicate by interferometric measurements the distance of penetration of light into the second medium at total reflection. It was found that intensity of the superficial wave is greater when the electric vector of the incident light is in the plane of incidence than when it is perpendicular to the plane. The reflection coefficients in the two cases were photometrically compared when the second medium was absorbing by means of a method of multiple reflection. The values of the absorption coefficient and the refractive index of the liquid measured in layers were compared with theoretical values obtained from equations for the reflection coefficients. It is concluded that for a saturated aqueous solution of $KMnO_4$ the solvent is preferentially adsorbed at the surface resulting in a smaller adsorption of the superficial wave than a wave traveling in the bulk of the liquid. **IV. Double refraction of interfacial layers of the normal aliphatic acids.** A. M. Taylor and Allen King. *Ibid.*, **23** [9], 308–12 (1933).—The critical angle of reflection from glass to liquid of three normal fatty acids, undecylic, lauric, and myristic, was determined by the apparatus of the second method, improved optically and contained in an air thermostat. The surface layers of the liquid phase were observed to become suddenly birefringent within a small range of tem-

perature near the temperature of solidification, indicating orientation of the molecules of the molten acid to a depth of at least 200 mol. R.H.H.P., Jr.

Titrimetric determination of small amounts of potassium. Werner Selke. *Landw. Vers.-Sta.*, **114**, 321–42 (1933).—The cobaltinitrite method of Dirks and Scheffer (see this issue, p. 222) is used for small amounts of K. The precipitation is carried out in concentrated solutions without cooling. The oxalic acid titer of 0.02 *N* $KMnO_4$ solutions containing H_2SO_4 varies with the duration and intensity of heating, the moment of addition of the acid, and the dimensions of the heating vessel. These factors can be kept sufficiently small and constant to give the accuracy required for the determination of K in soil extracts. The K factor decreases with increasing concentration of K in the test solution approaching a limiting value: 1 cc. of 0.02 *N* $KMnO_4$ = 0.1595 mg. K_2O. (*C.A.*)

Variation with temperature of the electrical conductivity of some hydrous materials. S. Shimizu. *Jour. Inst. Elec. Eng. Japan*, **53**, 465–74 (1933).—The conductivities of clay, kaolin, etc., vary continuously or discontinuously with temperature and seem to be related to the degree of hydration. See also *Ceram. Abs.*, **12** [7], 279 (1933). (*C.A.*)

BOOK REVIEWS

Annual Tables of Constants and Numerical Data. Index to Vol. IX (1929). 124 + xxiv pp. Gauthier-Villars et Cie, Paris; McGraw-Hill Book Co., Inc., New York, 1932. This supplementary volume to Vol. IX contains an alphabetical index in French, German, and English and a formula index giving page references to chemical elements and compounds for which data are given in Vol. IX.

Treatise on Mineral Chemistry (Traité de Chemie Minérale). **Vol. V.** Edited by P. Pascal. xxiii + 871 pp. Masson et Cie, Paris, 1932. Price 165 F. Ten authors assisted Pascal to write Vol. V of this treatise, which in its scope and size resembles Newton Friend's Textbook more closely than Mellor's Comprehensive Treatise. Picon has written the chapter on carbon, J. Amiel that on the compounds of carbon with bivalent elements, and P. Brun that on cyanogen and its compounds with other elements. A. Mialhe contributes an interesting and useful chapter on the solid, liquid, and gaseous fuels which play an important part in modern life. The section on silicon is the work of M. Samsoen, to which Pascal has added some pages on the nitrogen derivatives such as silylamines and silylimides. Chapters on titanium by M. Billy, germanium by J. Bardet and A. Tchakirian, zirconium and celtium (the name preferred to hafnium) by H. Pied and P. Camescasse, and the ammonium salts by P. Pascal complete the text. The true quality of a treatise such as this can only be correctly judged after constant use over a period of time, but a cursory reading makes a favorable impression. The volume is well printed and spaced; the subject matter is clearly presented and appears to be up to date, while the absence of abbreviations from the text is a matter for congratulation. The diagrams, although not numerous for a work of this size, are clearly printed if somewhat small, and selected physicochemical data are also incorporated. Many unfamiliar compounds are briefly described and make the text sufficiently complete for most purposes. The mineral silicates are not treated collectively in this volume; they are reserved for separate discussion under the appropriate metals in succeeding volumes. The inclusion of the section on the ammonium salts seems out of place here and should have been made in or nearer to the volume which deals with nitrogen. No claim is made that the references are exhaustive, but they are numerous and their arrangement is such that the authority for a statement in the text can quickly and easily be found. This is an excellent feature of the work which, unfortunately, is marred by the inconsistent and often incorrect ways in which abbreviations to the titles of a journal are made. Author's names are sometimes wrongly spelled and will look unfamiliar to an English reader. A little more care in this connection would have removed an irritating blemish from a work which should prove of much value to many chemists. (*Chem. & Ind.*)

BOOKS

Crystal Chemistry (Kristallchemie). O. Hassel. Theodor Steinkopff, Dresden, 114 pp. Reviewed in *Ind. chimique*, **21** [243], 305 (1934).—The purpose of this book is to give a review of the development of this science. The chief topics are (1) range of action of atoms and ions in crystals, (2) importance of polarization when studying crystal structure, (3) isomorphism and morphotropism in relation to the size of ions and their deformability, (4) crystalline chemistry of simplest compounds, (5) Pauling's rule relative to the structure of ion crystals, (6) crystalline chemistry of silicates, (7) crystalline chemistry of molecular combinations, (8) geometrical determination of the molecular weight in solid state, and (9) rotation of molecules of radical ions in crystals. M.V.K.

Metallurgical Analysis by the Spectrograph. D. M. Smith. British Non-Ferrous Metals Research Assn., London. 110 pp. Price 10s 6d. Reviewed in *Mining & Met.*, **15** [329], 240–41 (1934).—The theoretical basis of spectrography is discussed, with a description of the 60° Cornu prism spectrograph and the Littrow type of spectrograph. Two chapters deal with standardization of technique, two with methods of quantitative analysis, and the remainder with data for quantitative estimation of impurities in metals by means of the internal standard method with visual comparison of intensities. E.J.V.

Modern Thermodynamics. E. A. Guggenheim. xvi + 206 pp. Methuen and Co., London, 1933. Price 10s 6d net. Reviewed in *Nature*, **133** [3360], 431–32 (1934).—The work will be valuable to the mathematical student because of its orderly and systematic manner and to the physical chemist as a reference work for the general theory of thermodynamics. It is not an introductory text. J.L.G.

Thorpe's Dictionary of Applied Chemistry. Supplement Vol. I. A–M. G. J. F. Thorpe and M. A. Whiteley. Longmans, Green & Co., London. 680 pp. Price £3. *Colliery Guard.*, **148** [3831], 1008 (1934).—Advances in chemistry during the seven years since the last volume of the present edition was published are described. E.J.V.

PATENTS

Making base-exchange silicates. K. P. McElroy (Permutit Co.). U. S. 1,961,902, June 5, 1934. In the manufacture of base-exchange silicates by the fusion of materials containing alumina and silicates with alkali, the improved process comprises igniting in the presence of air a pervious mixture of fuel, a material containing alumina and silica, and an alkali, passing air through the mixture to heat the materials by combustion of the fuel, thereby producing a sintered mass, and subsequently leaching the sintered material with water.

Manufacture of potassium borate. Alfred Newman (Pacific Coast Borax Co.). U. S. 1,961,073, May 29, 1934. A process of producing potassium pentaborate comprises heating a sodium borate in acid solution with an inorganic potassium salt in proportions to yield a composition containing the potassium and boron compounds present calculated as potassium oxide and boric oxide in the ratio of between 1:6 and 1:10, to form potassium pentaborate, and separating potassium pentaborate from the reaction product.

Manufacture of precipitated silica. S. S. Svendsen (Clay Reduction Co.). U. S. 1,959,747, May 22, 1934.

Manufacture of synthetic spinels. Hermann Espig (I. G. Farbenind. A.-G.). U. S. 1,913,480, June 13, 1933. A synthetic spinel having a permanent aquamarine color consists of about 92 parts of alumina, 8 parts of magnesia, 0.12 part of chromic oxide, 0.025 part of cobaltic oxide, and 0.3 part of titanic oxide.

Process for recovering the lithium contained in siliceous lithium-bearing minerals. Metallges. Akt.-Ges. and H. H. Hutte Ges. Brit. 409,636, May 9, 1934.

Production of precipitated silica. S. S. Svendsen (Clay Production Co.). U. S. 1,959,748, and 1,959,749, May 22, 1934.

General

Application of statistical methods in foundry operation. F. Brinckmann and A. Nehmitz. *Giesserei*, **21** [17–18], 173–78 (1934).—The use of frequency or statistical curves for detecting and determining causes of defects and for supervision of raw materials and the use of such statistics to find relations in certain occurrences in the operation, for instance the amount of rejections in relation to composition, are explained and illustrated by curves. M.H.

Ceramic education. F. H. Norton. *Bull. Amer. Ceram. Soc.*, **13** [6], 150–51 (1934).

Clayworking in the East. I–II. Anon. *Brit. Clayworker*, **42** [503], 352–55; **43** [505], 50–53 (1934).—The first article gives a brief description of clayware manufacture in such places as Iraq, Singapore, Shanghai, etc. The second article gives a detailed description of the clayworking industry in India. Its object is to place on record the early development of that industry and its rise to the present dimensions. R.A.H.

Comments on ceramic education. J. L. Carruthers. *Bull. Amer. Ceram. Soc.*, **13** [6], 146–50 (1934).

Edward Orton, Jr., Ceramic Foundation. Editorial. *Bull. Amer. Ceram. Soc.*, **13** [6], 145–46 (1934).

Fireproof coats of water-glass. Anon. *Diamant*, **56** [12], 138 (1934).—(1) Four parts of borax and potash are dissolved in 100 parts water and this solution is mixed with 100 parts water-glass. (2) Twenty-five parts of heavy spar and 1 part of zinc oxide are mixed with 20 parts water and 25 parts water-glass. M.V.K.

Iron oxide and grog firing. Beninga. *Tonind.-Ztg.*, **58** [32], 389–90 (1934).—The thermal dissociation of iron oxide during grog firing with resulting swelling and porosity increase is discussed. M.V.K.

Just simple problems but it saves money to solve them. Anon. *Brick Clay Rec.*, **84** [5], 174–76 (1934).—The trouble of brick faces sticking together on the drier cars was solved by rigging up a means of dusting clay dust onto the clay column as it came out of the die. To remove roots and foreign matter from clay, a "comb" was placed over the conveyer belt from the crusher to the pug mill at an angle and not only were small roots removed, but also larger pebbles, pieces of wood, or nails, resulting in better cut brick and fewer cutting wires being broken. Better clay tempering was obtained by making sure the water was worked thoroughly through the clay mass, using a series of sprays in place of a single stream of water. E.J.V.

Machinery insurance. W. Koerner. *Eng. Progress*, **15** [4], 63–64 (1934).—The topics covered are (1) the necessity of machinery insurance to avoid an unforeseen accident upsetting the expense account or endangering the economy of the plant; (2) the scope of the insurance which covers accidents due to clumsiness, negligence, malevolence, defects in the structure of the machine, short circuits or lightning, explosions and disruption due to centrifugal force, and damage from storm; (3) indemnification; and (4) effect of insurance on the construction, material, and attendance. J.L.G.

Management methods for enamel plant cost control. I. Standard costs. Roy E. Dybvig. *Better Enameling*, **5** [5], 18–20 (1934).—Compilation of the cost data is the foundation on which standard costs are established. Costs are divided into the following groups: (1) labor; (2) direct expenses; (3) fixed expenses; (4) enamel material; (5) administration and selling expenses. The type of production must be divided into classes, such as by size and shape of the piece or by the number and nature of the operations. Means of setting the cost standards are discussed. Examples of the various accounts mentioned are given. E.J.V.

Manufacture and uses of rock wool. M. F. Goudge. *Chem. Eng. Mining Rev.*, **25**, 227 (1933).—Rock wool is a furnace product made from self-fluxing siliceous and argillaceous dolomite in which the acidic and basic constituents are present in such proportion that their fluxing action is nearly balanced. Its principal use is as an insulating material. It also forms the main ingredient in an acoustic tile. It resists temperatures up to 538°, is fire-

proof, vermin-proof, and odorless. Rock wool is closely akin to glass wool and slag wool. (*C.A.*)

Materials of chemical plant construction. III. Lead. ALFRED H. LOVELESS. *Ind. Chemist*, **8**, 289–90, 310–12, 352–53 (1932). **IV. Iron and steel.** *Ibid.*, **8**, 387–90, 442–44 (1932); **9**, 26–29 (1933). **V. Refractories.** *Ibid.*, **9**, 99–101, 126–28, 161–63 (1933); for Part II, "Clays and clay products," see *Ceram. Abs.*, **11** [10], 540 (1932). (*C.A.*)

Modern care of feed water. R. KLEIN. *Glückauf*, **69** [46], 1077–85 (1933).—The causes of destruction of boilers, types of corrosion due to chemical, physical, and mechanical attack, prevention by feed-water softeners, and adjusting of alkalinity and acidity, etc., are discussed at length. M.H.

New abstracts of silicate literature. S. I. PERKAL. *Bull. Amer. Ceram. Soc.*, **13** [6], 174 (1934).

Power costs by oil engine and electric motor. J. V. BRITTAIN. *Brit. Clayworker*, **43** [504], 6–8 (1934).—Two cases of power costs of electrically driven brickworks are discussed, one producing brick (wire-cut) from hard shale and the other producing wire-cut brick from field clay. B. attempts to show how closely estimated annual costs will agree with actual costs in normal operation. For previous abstract see *Ceram. Abs.*, **13** [4], 104 (1934). R.A.H.

Relationship between heat accumulation and thermal conductivity of ceramic materials. W. DAWIHL. *Tonind.-Ztg.*, **58** [32], 387–88 (1934); *Keram. Rund.*, **42** [15], 183–84 (1934).—With the same thermal conductivity, bodies with higher specific heat, *i.e.*, with a greater capability of accumulating heat, absorb temperatures more slowly and also cool more slowly. The specific heat of various ceramic materials differs little. Because the specific heat of mixtures can be additively calculated from the separate constituents, calculation of the capability of a body containing air to accumulate heat is possible. Calculations show the relation between the capability of accumulating heat, thermal conductivity, and specific gravity, and how much it is possible to affect arbitrarily the first two properties. M.V.K.

Silica content of normal and silicotic lungs and its bearing on the problem of silicosis. F. S. FOWWEATHER. *Refrac. Jour.*, **10** [5], 173–77 (1934).—F. describes the results of investigations of lungs of miners, asbestos workers, sandblasters, and others who have worked in an industry believed to carry a risk of silicosis. From these investigations he concludes that the determining factors for silicosis are (1) not the amount of silica but its nature, *i.e.*, silica in some forms is a much more potent agent for producing silicosis than in other forms, and (2) not solely the amount of silica present, but certain conditions in the body of the person into whose lungs the silica gains access. A.J.M.

Silicosis: the minerals which cause it. W. R. JONES. *Refrac. Jour.*, **10** [5], 177–85 (1934).—J. shows several microphotographs of silicotic lungs and of dusts from several localities. For abstract see *Ceram. Abs.*, **13** [4], 105 (1934). A.J.M.

Silicosis. Pathological aspect of causation. Determining the disease. BENJAMIN F. TILLSON. *Eng. Mining Jour.*, **135** [4], 167–70 (1934).—T. considers that the silica molecule is probably responsible for the toxic effect whether free or combined as in the case of sericite and chrysotile asbestos. The theories advanced to explain the action of silica on cell structure are mentioned. A silicotic condition increases susceptibility to tubercular infection. Over 75% of silicotics die of tuberculosis. Both tubercular and syphilitic conditions increase susceptibility to silicosis. Five phases of disposal of mineral dusts by phagocytes and the corresponding pathology are given. Six factors to be considered in diagnosing the disease are listed. Three stages of the disease with their characteristic symptoms are described. Seven possible sources of errors in diagnosis are explained. The necessity for several X-ray views in confirming the diagnosis is stressed. The desirability of a method for detecting and determining the nature of mineral dusts in living lungs is discussed. The present methods of analyzing lung tissue (post mortem analyses) are described and their weak points indicated. The need for an optical technique of analysis using the petrographic microscope is urged. T. also points out that the particles remaining undissolved in the lungs for analysis are not the ones that have done the damage. See also *Ceram. Abs.*, **13** [7], 195 (1934). J.L.G.

Some chemical observations on silicotic and anthracotic lungs. F. V. TIDESWELL. *Refrac. Jour.*, **10** [5], 185–86 (1934).—T. describes a method of analysis used to determine total silica, insoluble organic matter (coal), and insoluble mineral matter in silicotic and anthracotic lungs. A.J.M.

BOOK REVIEW

Annual Survey of American Chemistry. Vol. VIII. 1933. Published for NATIONAL RESEARCH COUNCIL by the Chemical Catalog Company Inc., 330 W. 42nd St., New York, N. Y. 403 pp. Price $4.50. Each of the 25 chapters in the book is written by a recognized authority in the field of pure or applied chemistry. Six chapters of particular interest to ceramists are, (4) thermodynamics and thermochemistry, (7) structure determination by X-ray and electron diffraction, (9) analytical chemistry, (18) chemistry of the silicates, (19) ceramics, and (25) gaseous fuels during 1932 and 1933. G. W. Morey of the Geophysical Laboratory contributed the chapter on chemistry of the silicates; that on ceramics was written by E. W. Tillotson of the Mellon Institute. The most noteworthy advances of the year are mentioned and a bibliography is included at the end of each chapter. Due to the large field assigned to each man it is not surprising to find some papers overlooked. Also due to the limited space available only mention is made of most papers. The book is a good summary of the year's advances and the bibliography appended to each chapter makes it easy to refer to the original articles. A.J.METZGER

PATENT

Mask. ROBERT MALCOLM. U. S. 1,960,544, May 29, 1934.

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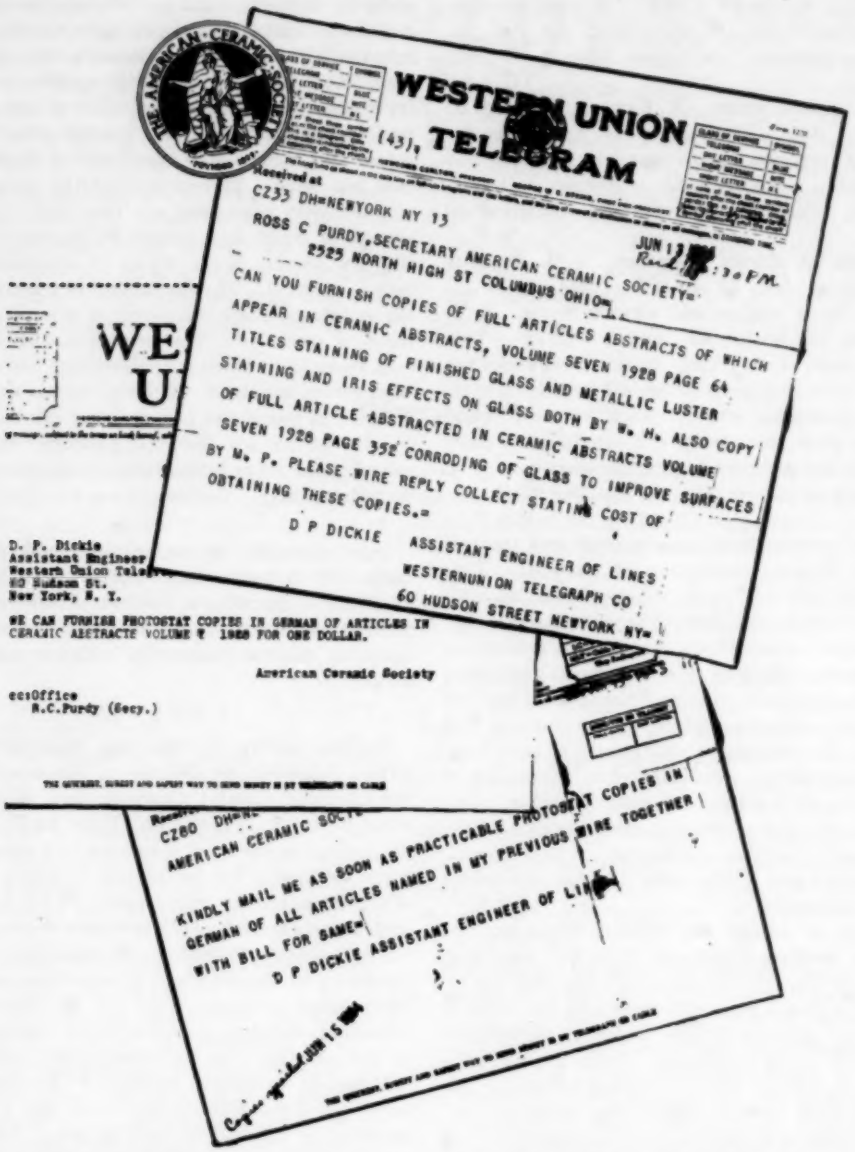

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